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Post-Operative Sensitivity Following Composite Resin Restoration: A Guide for Prevention

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Abstract

One of the main causes of dental visits is pain, and clinical findings show that patients complain of dentinal sensitivity in a variety of settings and to varying degrees of severity. Even in cases where there is no obvious deterioration in the restoration, this is a very common issue following resin composite dental restorations. This bibliographic research aimed to determine the reasons behind post-operative sensitivity in resin composite restorations and provide preventative measures so that practitioners might utilise this knowledge to lessen the incidence of this annoyance in their day-to-day work. Analysis was done on the entire texts of pertinent articles. Post-operative sensitivity in direct resin composite restorations can have a number of causes, including errors in diagnosis, treatment indications, cavity preparation, material insertion, hard dental tissue hybridisation, finishing, and polishing the restoration. In order to prevent or reduce the likelihood of post-operative sensitivity, it is essential at every stage of the restorative process that an accurate diagnosis should be made, and appropriate method should be employed.

Keywords: - *Composite, Sensitivity, Post-Operative, Immediate Dentin Sealing, Decoupling.*

Introduction

Over the past several years, amalgam restorations have been replaced by more aesthetically pleasing restorations, particularly those made of resin. (3)

Despite significant advancements, restorative techniques still experience a certain rate of failure. The primary issues contributing to restoration failures include discoloration, marginal leakage, recurrent caries, and loss of the restoration. Class I and II resin composite restorations are particularly prone to these problems. One of the most perplexing and difficult challenges is post-operative dentin sensitivity, which is a notable drawback of using direct resin composites. (3)

The primary morphological feature of dentin is its tubular structure, filled with fluid, which connects the pulp to the enamel-dentin junction. Surrounding the lumens of these dentinal tubules are thin cuffs of mineralized tissue known as peritubular dentin. The intertubular dentin, the matrix between these cylindrical structures, contains about 30% by volume of mineralized type I collagen fibrils, oriented perpendicular to the tubules' long axis (13,14). In contrast, peritubular dentin has a much smaller collagen content, about 10% by volume (13). This structural pattern directly influences dentinal permeability, which increases as one moves closer to the pulp. The porosity and diameter of the tubules also increase near the pulp chamber, with values ranging from 45,000–65,000/mm² near the pulp, 29,500–35,000/mm² in the intermediate region, to 15,000–20,000/mm² at the enamel-dentin junction. The tubule diameters are approximately 2.5 µm near the pulp, 1.2 µm in the intermediate region, and 0.5 µm at the enamel-dentin junction. This explains the increased dentin permeability in the area close to the pulp chamber.

In 1962, Brännström provided the first explanation of the physiology of pulpal pain. In his thesis, he also characterized the hydrodynamic theory of fluid movement. Mechanoreceptors close to the odontoblast processes are stimulated by dentinal fluid movement in the tubules, resulting in indirect innervations that induce pain. The amount of fluid flow created determines how the pulpal nerves react. Pulpal C-fibers react to bradykinin or capsaicin, while A-delta fibers are stimulated by dentinal tubules (e.g., airblast). Pulpal inflammation is mediated by pulpal C-afferent fibers, but dentinal sensitivity is mediated by pulpal A-delta fibers, according to this study. (1) This explains the main mechanism of sensitivity which might occur after restorations

Post-operative sensitivity in resin composite restorations has a variety of causes and is a common occurrence that causes discomfort in the patient as well as trouble to the professional.

Despite being prevalent, the cause is yet unknown. As a result, it's critical to research the issue and create a work schedule that will prevent it. (3) Managing post-operative sensitivity can be challenging. Patients frequently report varying degrees and intensities of sensitivity, without any indication that the restoration is failing.(1) The more commonly reported manifestations include temperature sensitivity especially to cold and masticatory sensitivity

Post-Operative Dentinal Sensitivity

Pain during chewing or sensitivity to hot/cold or sweet stimuli that occurs for a week or longer after retoration is Post-operative Sensitivity

It can be further divided into 2 types:

1. Sensitivity which subsides after a week
   This is more commonly seen in small to moderate sized restoration and in restoration which has high points

2. Sensitivity which does not subside for a long time
   This is seen in deeper carious lesions with minimal remaining dentinal thickness and can also be seen in lesions where repeated restorative therapies cause pulpal irritation

Causes

The main cause for sensitivity is the dentinal fluid movement, but there are a lot of stimulus which can lead to this fluid movement including dentin dehydration, temperature variation, penetration of chemicals or bacteria, microleakage around restoration due to – marginal gap, voids, degradation of bonding agents, degradation of smear layer, varying coefficient of thermal expansion of restoration and polymeristion shrinkage.

Many procedural errors can lead to the above mentioned stimulus and cause sensitivity.

So, it is important to know these errors and prevent them or modify the procedures to prevent this kind of frequent complication in resin restorations

Caries Excavation

Increased caries depth is linked to a higher risk of post-operative sensitivity (POS) due to the greater number and size of dentinal tubules exposed to pulpal irritation or microleakage. Dry cutting dentin and using blunt burs can create frictional heat, further contributing to POS. To mitigate this, clinicians are advised to use intermittent cutting techniques, ensure sufficient water irrigation during cavity preparation, and replace worn-out burs to enhance cutting efficiency and reduce heat-induced pulpal damage.

Etching Time and Strategy

Prolonged etching time (over 15 seconds) can cause morphological changes on the dentin surface, such as widened tubule openings, increased tubule diameter, and greater smear layer dissolution, leading to deeper dentin demineralization. While these changes can enhance mechanical interlocking and resin tag formation, they negatively affect hybridization. Accidental over-etching can create a demineralized dentin depth exceeding 5 microns, which may surpass the adhesive's penetration ability. This results in a weaker hybrid layer with gaps that promote nanoleakage, thereby increasing susceptibility to post-operative sensitivity (POS). Additionally, extended acid exposure can denature fragile collagen fibers, increasing dentin permeability.

There is extensive literature discussing the choice between self-etch and total-etch techniques to prevent post-operative sensitivity (POS), with findings that are often mixed and contradictory. Some studies indicate that self-etch strategies are more effective in reducing immediate sensitivity within 24 hours for deeper caries lesions compared to the total-etch technique. However, current evidence shows no significant difference in POS between the two methods.

Adhesive Application

Pooling of adhesive due to insufficient air thinning can lead to improper solvent evaporation and incomplete polymerization. Similarly, inadequate adhesive coating can result in micro/nanoleakage at the tooth-restoration interface, leading to post-operative sensitivity (POS). Therefore, it is crucial to follow the manufacturer's instructions closely when applying adhesive.

Dentin moisture levels also influence POS occurrence. Excessive drying can cause the dentin collagen matrix to collapse, resulting in incomplete monomer penetration and voids. Consequently, despite contradictory clinical reports, water or ethanol wet bonding techniques have been preferred over the years.

Incremental versus Bulk Filling

Traditionally, the incremental filling technique involves placing composite resin in layers no thicker than 2 mm. This method aims to ensure proper polymerization, improve how well the filling fits against the tooth's edges, and reduce shrinkage by minimizing the C-factor. However, it carries risks such as potential voids between layers, formation of gaps along the edges, and the risk of contamination, making it a time-consuming process.

In contrast, bulk-fill resins have been developed to simplify and speed up procedures by allowing for thicker increments of 4 to 5 mm. These modern materials have demonstrated good conversion rates, low shrinkage, and effective curing depths even at greater thicknesses like 4 mm.
Despite these advantages, some studies caution that using bulk placement of conventional non-bulk-fill composites in deep cavities can lead to problems like cuspal deflection and stress at the adhesive interface, which can clinically manifest as post-operative sensitivity (POS).
In their comparison of the two techniques, Costa et al. (6) found that the overall risk of immediate POS was not significantly influenced by whether incremental or bulk-fill techniques were used. They concluded that the clinical outcomes regarding POS in direct posterior restorations were similar with both techniques, suggesting that the choice between them may not have a substantial impact on the development of POS.

Curing

Insufficient curing of bonding resin results in incomplete polymerization, which can lead to sensitivity (12). If light-curing devices do not achieve the recommended irradiance levels (300 to 400 mW/cm²), they fail to adequately polymerize the resin, causing the release of unreacted monomers and camphorquinone into the pulp, which can be harmful (13, 28). It is crucial to ensure that curing devices are sufficiently powerful and have the appropriate tip diameter (approximately 8 mm) to allow light to penetrate fully to the base of the cavity preparation (15, 28).
Additionally, employing a soft-start curing mode initiates gradual polymerization, reducing shrinkage within the filling and potentially lowering the likelihood of post-operative sensitivity (29). During use, light-curing units should be stabilized intraorally with the operator's fingers and positioned perpendicular to the tooth surface. Starting at a distance of 1 cm from the restoration, the device should be moved closer gradually to ensure effective curing (28).

Finishing and Polishing

To minimize issues with post-operative sensitivity (POS), it is recommended to restrict finishing and polishing to minor adjustments in contour and superficial smoothing. Excessive removal of composite material during finishing can disrupt the resin matrix, interfere with the final stages of polymerization after light exposure, and remove the well-polymerized surface layer (13).
Studies suggest that for microfilled composite restorations placed on dentin margins, finishing with diamond burs under wet conditions 24 hours after placement significantly reduces microleakage, thereby lowering the frequency of POS (30).

Preventing Postoperative Sensitivity

The pre-existing conditions of a tooth, such as the size, depth, and location of lesions, anatomical variations, presence of microcracks, preexisting hypersensitivity, defects in enamel or dentin, and the health of the pulp, can contribute to the onset of post-operative sensitivity (POS) (13, 15). While these factors are beyond direct control, clinicians can prevent POS by focusing on effective restorative strategies and minimizing errors in technique during the placement of direct composite restorations.Additionally, operators can reduce the occurrence of POS by staying updated on their skills and knowledge regarding the specific characteristics of materials used, appropriate handling techniques, as well as understanding the indications and limitations of each material. This proactive approach helps in optimizing the clinical outcomes and reducing potential complications like post-operative sensitivity.

Reducing Technique-Related Errors

Before commencing restorative treatment, clinicians should thoroughly examine the tooth for factors that could contribute to sensitivity, such as abrasions, exposed cervical dentin, pulp inflammation, defects in enamel or dentin, or similar issues. Depending on the specific clinical conditions observed, various strategies can be employed at each stage to minimize the risk of post-operative sensitivity (POS), as outlined in Table 1.
After treatment, it's important to consider the possibility of incomplete tooth fractures that may mimic POS, especially in cases involving extensive caries preparations. If such fractures are identified, they should be accurately diagnosed and managed accordingly. In instances where POS persists despite the restorative treatment, replacing the restoration may be necessary to address the underlying cause effectively. This approach ensures optimal patient comfort and long-term restoration success.

Choice of Material

In adhesive dentistry, the adhesive material chosen is less critical compared to the technique used to minimize the risk of post-operative sensitivity (POS) (19). The skill and experience of the operator significantly influence POS outcomes (31). Novice practitioners often start with simpler single-step adhesion techniques, whereas more experienced operators may prefer complex multistep adhesive systems that can effectively reduce POS incidence (31).
To address preoperative dentin exposure-related hypersensitivity and potentially reduce POS, the use of dentin desensitizers before acid etching in deeper caries preparations has been considered (15, 32). Common desensitizers include glutaraldehyde/hydroxyethylmethacrylate, chlorhexidine, fluoride-based agents, and potassium oxalate. While these desensitizers have shown success in managing dentinal hypersensitivity before restorative procedures, clinical trials have not demonstrated significant benefits when used under direct or indirect restorations (5, 33, 34). Moreover, most desensitizers, including oxalate and fluoride-based agents, can compromise the bond strength of adhesives to dentin (35).
Various liners, such as resin-modified glass ionomer and calcium hydroxide, have been investigated for their potential to reduce POS (36). However, a Cochrane review concluded that liners generally do not provide additional benefits in minimizing POS unless they are specifically intended for therapeutic purposes. The review noted insufficient data and a high risk of bias in existing studies to make definitive clinical recommendations (36).

TABLE 1. Technique-Related Considerations and Strategies for Reducing Postoperative Sensitivity After Direct Composite Restorations

Restorative Stage	Technique Error/Problems	Strategies to Reduce Postoperative Sensitivity
Caries Excavation	Increased preparation depth	• Use selective caries excavation procedures, where indicated • Consider using a liner/desensitizer*
	High temperature/high pressure drills with inadequate cooling	• Avoid the use of blunt burs • Replace worn-out diamond burs and abrasives periodically • Use copious water stream to prevent pulpal irritation from frictional heat • Intermittent cutting of tooth structure
Etching	Over etching	• Etch enamel for 15 seconds and dentin for five seconds when using total-etch techniques • Consider self-etch adhesives or selective enamel-etch techniques in deeper preps*
Adhesive Application	Dentin dehydration	• Avoid repeated or excessive cavity drying • Keep dentin surface moist while bonding using water or ethanol wet bonding techniques
	Pooling of adhesive	• Apply a thin layer of adhesive and rub for 20 seconds to ensure penetration • Dry for five seconds using an air syringe to allow solvent to evaporate
	Inadequate spread of adhesive	• Apply multiple thin layers to ensure adequate coverage of adhesive
Restoration	Restoration voids	• Consider flowable composite as first increment/layer or liner* • Use low-shrinkage composites • Avoid bulk-curing conventional non-bulk-fill composites
	Unfavorable C-factor/multi-surface restorations	• Use oblique layering to reduce C-factor
Curing	Improper curing	• Select a soft-start curing light mode to reduce shrinkage • Orient curing device perpendicular to the tooth • Curing distance: 0 to 1 cm; curing time: 10 to 20 seconds • Air-cool the restoration while curing to prevent heat buildup • Periodically assess light-curing device output with a radiometer • Avoid bulk-curing conventional non-bulk-fill composites
Finishing and Polishing	Over contoured or overbuilt restorations	• Do not place a large excess of material • Avoid aggressive overuse of burs and abrasives • Restrict to minor contour adjustments • To prevent failure at the tooth-restoration interface, do not over-polish • Check for high-points in static, as well as excursive, occlusion • Wet-polish after 24 hours to reduce frictional heat

* Note: Strategies denoted with an asterisk have a disputed or inconclusive evidence base.

Flowable composites, known for their low viscosity and elastic modulus, theoretically offer better marginal adaptation and reduced microleakage when used as the initial increment (23). However, clinical trials have shown limited evidence of their effectiveness in reducing microleakage or improving overall clinical performance to mitigate POS (37). Similarly, low-shrinkage resins and bulk-fill ormocers are thought to induce less POS due to their reduced polymerization shrinkage. Yet, a meta-analysis determined that this effect is statistically insignificant, and both types of materials are clinically comparable in terms of POS (38).
Emerging strategies like low-level diode laser irradiation before resin placement and air abrasion of preparations using a 50-micron aluminum oxide microetcher have shown potential in reducing microleakage-related POS (39, 40). However, robust clinical trials are needed to establish their efficacy and validate these techniques for preventing POS effectively.

Newer Techniques

1.Dentin Desensitizer

They act by reduction in the diameter of the dentinal tubules so as to limit the displacement of fluid in them, this in turn help in reduction of dentinal hypersensitive reactions, thus a layer or two of the desensitizer before placing of the final restoration helps in reducing postoperative sensitivity.
Various agents which are used include Glutaraldehyde, Chlorhexidine, Hydroxyethylmethyl acrylate etc.
Recent Dentin Bonding Agents such as Gluma desensitizing agent contains Glutaraldehyde-protein coagulation within dentinal tubules.Its use might compromise the bond strength

2.Low-Level Diode Lasers Irradiation

Irradiation with lasers help to occlude dentinal tubules by photoablation and second mechanism is
modification of tubular structure of dentin by melting and fusing of the hard tissue or smear layer and subsequent sealing of the dentinal tubules.

3.Air Abrasion

Abrading the dentinal surface with 50 microns Aluminium oxide microetcher before the placement of final restorative material can reduce microleakage related post operative sensitivity by cleaning the surface of any residual debris or smear layer and thus increasing the surface area for the restorative material to form micromechanical bond with the tooth surface

4.Immediate Dentin Sealing

It was first introduced by Pascal Magne in 2005,Freshly cut dentin is susceptible to bacterial contamination during provisionalization period, the colonization of bacteria through the exposed dentinal tubules leads to post-operative sensitivity and a compromise in bond strength. So whenever dentin is exposed, the application of a dentin bonding agent is recommended.

Dentin bonding strength is weaker when subjected to occlusal forces immediately in direct restoration because demineralized dentin can easily collapse by the seating pressure of the restoration. Whereas Stress-free dentin bond development improves restoration adaptation.

Freshly cut dentin is the ideal substrate for dentin bonding. Thereby creating a hybrid layer that both mimics the dentino-enamel junction (DEJ) and promotes proper adaptation and adherence of the final restoration is the basis of minimal intervention dentistry. When filled adhesives are precured the strength of restoration is improved.

Dentinal tubules are blocked by the movement of dentinal tubule fluids which hinder the penetration of the resin into them. It also provides several advantages like limiting the needs for anesthesia during insertion, increase in retention when combined with GIC, RMGI cements, improving the cohesive strength of the tooth.

The procedure includes identifying the dentinal surface for which use of magnification is a pre-requisite. It is then followed by selective etching of enamel for direct composite restorations and only dentinal etching for indirect restorations. Then the filled adhesive is applied specifically on dentin using a periodontal probe or any sharp instrument and light cured for 20 seconds, after which a layer of flowable composite is placed to immediately seal the dentinal tubules. Following this final resin restoration can be placed. The last layer of the resin increment should be free from the oxygen inhibition layer so as to get an accurate impression for indirect restorations, this can be done by curing the last layer through a bio-fit matrix or use of glycerine gel while curing.

5.Decoupling with Time

Decoupling with time (DWT) is a process that involves delaying the subsequent layering of the dentin hybrid layer and the restorative layers. This gives the dentin hybrid layer time to mature and strengthen in a stress-free environment, with less influence from polymerization forces. DWT can help overcome the differences between the various types of dental hard tissue involved in bonding procedures.

This concept of first establishing a bonded seal of the dentin with a thin layer of resin and then, after a period of time, connecting or coupling the rest of the restoration to it has been referred to in the literature as "decoupling with time." Decoupling with time can help overcome the differences among the multiple types of dental hard tissue involved in bonding procedures

The free radical polymerization reaction that is forming the hybrid layer in dentin is completing 80% to 90% of its potential monomer conversion, which directly relates to it strength. The conversion of monomers to oligomers, then to small polymers, and finally, to larger polymers takes 5 to 30 minutes. The adhesive layer in the dentin bonding system needs to be a minimum of 80 µm thick to polymerize because 10 to 20 µm of its thickness will be inhibited from conversion by the air inhibiting of the dentin bonding system initiators that cause the start of monomer chain formation.(41)

The procedure includes to resin coat the immediately sealed dentin with a 0.5-mm layer of microfilled nanofilled flowable composite to increase the thickness of the adhesive layer of the dentin bonding system. Then allowing the dentin hybrid layer to settle for 5 to 30 minutes to mature before placing an overlying increment with a thickness greater than 1.5 mm. When the amount of dentin to be replaced is greater than 1.5 mm in thickness, using a stress-reducing direct composite layering technique to restore the dentin and then the enamel separately. (41)

Conclusion

The management of post-operative sensitivity (POS) lacks a universal solution due to the diverse factors involving the tooth, materials, and techniques. Therefore, clinicians are advised to assess and address these contributing factors before treatment initiation. It is crucial to tailor strategies by selecting appropriate measures, materials, and techniques for each patient's specific clinical scenario.

Clinicians should integrate research-backed recommendations into their practice for each phase of restorative treatment. Drawing on past successful experiences, they can establish standardized clinical workflows that enhance predictability and reduce the occurrence of POS. By adopting this approach, practitioners can achieve more consistent outcomes and ensure patient comfort throughout the treatment process.

References

[1] Prakash M. , Sheth N. , Khan M. , Kaur S. , Mong SS. , and Vaderhobli R. , Evidence-Based Approach to Avoid Postop Sensitivity in Adhesive Dentistry *Decisions in Dentistry.* July 2022;8(7)16-19.

[2] Sabbagh, Joseph & Fahd, Jean-Claude & Mcconnell, Robert. (2018). Post-operative sensitivity and posterior composite resin restorations: A review. Dental Update. 45. 207-213. 10.12968/denu.2018.45.3.207.

[3] Porto, Isabel. (2012). Post-operative sensitivity on direct resin composite restorations: clinical practice guidelines. *Indian Journal of Restorative Dentistry*. 1. 1-12.

[4] Briso AL, Mestrener SR, Delício G, et al. Clinical assessment of postoperative sensitivity in posterior composite restorations. *Oper Dent*. 2007;32:421–426.

[5] de Oliveira ILM, Hanzen TA, de Paula AM, et al. Postoperative sensitivity in posterior resin composite restorations with prior application of a glutaraldehyde-based desensitizing solution: A randomized clinical trial. *J Dent*. 2021;117:103918.

[6] Costa T, Rezende M, Sakamoto A, et al. Influence of adhesive type and placement technique on postoperative sensitivity in posterior composite restorations. *Oper Dent.* 2017;42:143–154.

[7] Berkowitz G, Spielman H, Matthews A, et al. Postoperative hypersensitivity and its relationship to preparation variables in Class I resin-based composite restorations: findings from the Practitioners Engaged in Applied Research and Learning (PEARL) Network. Part 1. *Compend Contin Educ Dent*. 2013;34:e44–e52.

[8] Auschill TM, Koch CA, Wolkewitz M, Hellwig E, Arweiler NB. Occurrence and causing stimuli of postoperative sensitivity in composite restorations. *Oper Dent*. 2009;34:3–10.

[9] Abbas B, Gulfam F, Anwar FS, Zara B, Aamer S, Zafar S. Influence of cavity depth and liner on postoperative hypersensitivity in posterior composite restorations. *Med Forum.* 2021;32:121–125.

[10] Hirata K, Nakashima M, Sekine I, Mukouyama Y, Kimura K. Dentinal fluid movement associated with loading of restorations. *J Dent Res*. 1991;70:975–978.
[11] Hayashi M, Wilson NH. Failure risk of posterior composites with post-operative sensitivity. *Oper Dent.* 2003;28:681–688.
[12] Brannstrom M. The hydrodynamic theory of dentinal pain: sensation in preparations, caries, and the dentinal crack syndrome. *J Endod*. 1986;12:453–457.
[13] Porto IC. Postoperative sensitivity in direct resin composite restorations: clinical practice guidelines. *IJRD*. 2012;1:1–2.
[14] Soares CJ, Faria-E-Silva AL, Rodrigues MP, et al. Polymerization shrinkage stress of composite resins and resin cements — What do we need to know? *Braz Oral Res*. 2017;31(Suppl 1):e62.
[15] Sabbagh J, Fahd JC, McConnell RJ. Post-operative sensitivity and posterior composite resin restorations: a review. *Dental Update*. 2018;45:207–213.
[16] Brajdić D, Krznarić OM, Azinović Z, Macan D, Baranović M. Influence of different etching times on dentin surface morphology. *Coll Antropol*. 2008;32:893–900.
[17] Cardenas AFM, Siqueira FSF, Bandeca MC, et al. Impact of pH and application time of meta-phosphoric acid on resin-enamel and resin-dentin bonding. *J Mech Behav Biomed Mater*. 2018;78:352–361.
[18] Yousaf A, Aman N, Manzoor MA, Shah JA, Rasheed D. Postoperative sensitivity of self etch versus total etch adhesive. *J Coll Physicians Surg Pak*. 2014;24:383–386.
[19] Reis A, Dourado Loguercio A, Schroeder M, Luque-Martinez I, Masterson D, Cople Maia L. Does the adhesive strategy influence the post-operative sensitivity in adult patients with posterior resin composite restorations? A systematic review and meta-analysis. *Dent Mater.* 2015;31:1052–1067.
[20] Hayashi M. Adhesive dentistry: understanding the science and achieving clinical success. *Dent Clin North Am*. 2020;64:633–643.
[21] Castro AS, Maran BM, Gutiérrez MF, et al. Dentin moisture does not influence postoperative sensitivity in posterior restorations: A double-blind randomized clinical trial. *Am J Dent*. 2020;33:206–212.
[22] Pashley DH, Tay FR, Carvalho RM, et al. From dry bonding to water-wet bonding to ethanol-wet bonding. A review of the interactions between dentin matrix and solvated resins using a macromodel of the hybrid layer. *Am J Dent*. 2007;20:7–20.
[23] Ferracane JL, Lawson NC. Probing the hierarchy of evidence to identify the best strategy for placing class II dental composite restorations using current materials. *J Esthet Restor Dent*. 2021;33:39–50.
[24] Soares CJ, Rosatto C, Carvalho VF, Bicalho AA, Henriques J, Faria-E-Silva AL. Radiopacity and porosity of bulk-fill and conventional composite posterior restorations — digital X-ray analysis. *Oper Dent*. 2017;42:616–625.
[25] Van Ende A, De Munck J, Lise DP, Van Meerbeek B. Bulk-fill composites: a review of the current literature. *J Adhes Dent*. 2017;19:95–109.
[26] Vinagre A, Ramos J, Alves S, Messias A, Alberto N, Nogueira R. Cuspal displacement induced by bulk fill resin composite polymerization: biomechanical evaluation using fiber Bragg grating sensors. *Int J Biomater*. 2016;2016:7134283.
[27] Arbildo-Vega HI, Lapinska B, Panda S, Lamas-Lara C, Khan AS, Lukomska-Szymanska M. Clinical effectiveness of bulk-fill and conventional resin composite restorations: systematic review and meta-analysis. *Polymers (Basel)*. 2020;12:1786.
[28] Price RB, Dickie D, Strassler HE. Guidelines for successful light-curing. *Inside Dental Assisting*. 2014;11(4):30–38.
[29] Alomari Q, Omar R, Akpata E. Effect of LED curing modes on postoperative sensitivity after Class II resin composite restorations. *J Adhes Dent*. 2007;9:477–481.
[30] Lopes GC, Franke M, Maia HP. Effect of finishing time and techniques on marginal sealing ability of two composite restorative materials. *J Prosthet Dent*. 2002;88:32–36.
[31] Sancakli HS, Yildiz E, Bayrak I, Ozel S. Effect of different adhesive strategies on the post-operative sensitivity of class I composite restorations. *Eur J Dent*. 2014;8:15–22.
[32] Mehta D, Gowda VS, Santosh A, Finger WJ, Sasaki K. Randomized controlled clinical trial on the efficacy of dentin desensitizing agents. *Acta Odontol Scand*. 2014;72:936–941.
[33] Chermont AB, Carneiro KK, Lobato MF, et al. Clinical evaluation of postoperative sensitivity using self-etching adhesives containing glutaraldehyde. *Braz Oral Res*. 2010;24:349–354.
[34] Eyüboğlu GB, Naiboğlu P. Clinical efficacy of different dentin desensitizers. *Oper Dent*. 2020;45:E317–E333.
[35] Li J, Hua F, Xu P, Huang C, Yang H. Effects of desensitizers on adhesive-dentin bond strength: a systematic review and meta-analysis. *J Adhes Dent*. 2021;23:7–19.
[36] Schenkel AB, Veitz-Keenan A. Dental cavity liners for class I and class II resin-based composite restorations. *Cochrane Database Syst Rev*. 2019;3:CD010526.
[37] Boruziniat A, Gharaee S, Sarraf Shirazi A, Majidinia S, Vatanpour M. Evaluation of the efficacy of flowable composite as lining material on microleakage of composite resin restorations: A systematic review and meta-analysis. *Quintessence Int*. 2016;47:93–101.
[38] Kruly PC, Giannini M, Pascotto RC, et al. Meta-analysis of the clinical behavior of posterior direct resin restorations: Low polymerization shrinkage resin in comparison to methacrylate composite resin. *PLoS One*. 2018;13:e0191942.
[39] Rezaei-Soufi L, Taheri M, Fekrazadas R, Farhadian M. Effect of 940 nm laser diode irradiation prior to bonding procedure on postoperative sensitivity following class II composite restorations: a split-mouth randomized clinical trial. *Lasers Med Sci*. 2021;36:1109–1116.
[40] Arora A, Acharya SR, Vidya SM, Sharma P. A comparative evaluation of dentinal hypersensitivity and microleakage associated with composite restorations in cavities preconditioned with air abrasion — An ex vivo study. *Contemp Clin Dent*. 2012;3:306–313.
[41] Alleman D, Alleman D, Deliperi S. Adhesion and bonding in composite direct and indirect restoration OHI-S. 2023 [cited 2024 Aug 21].