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Operator Errors In Failed Composite Restoration - A Review

Review Article

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Abstract

Objective: In this study the literature was reviewed to investigate the operator errors in composite restorations.
Data: Clinical studies investigating the survival composite restorations with at least three years of follow-up were screened and main reasons associated with restoration failure due to operator errors were chosen.
Sources: PubMed, Scopus, and Cochrane databases were searched without restriction on date or language. Reference lists of eligible studies were hand-searched.
Conclusion: Composite restorations fail for a variety of reasons, and the operator should do everything possible to avoid this, from case selection to finishing and polishing.

Introduction

Dental caries is still a very common disease that affects a large portion of the global population, especially the poor. Restorative procedures continue to be in high demand in clinical dentistry, with restoration placement (and replacement) accounting for a considerable portion of a dentist's time [1]. The quest for an artificial restorative material that mimics natural tooth function and attractiveness in the oral setting continues to be a top priority for dentists, leading to the use of a variety of restorative materials in dentistry [1, 2]. Composite resins have grown in popularity as restorative materials since their introduction, owing to their aesthetic properties and lower sound tissue removal rates. Composites technology has progressed steadily over the last few decades.

The public's demand for aesthetic dental restorations is obviously growing, and dentists are spoiled for options when it comes to which products to use and how to best use them. The excellent aesthetics that composite resin as a restorative material can achieve are undeniable; however, the durability of these materials can be disappointing, particularly if they are not placed using a careful incremental technique. Due to the increased use of these materials for the reconstruction of large defects in posterior teeth, they are being put to the test to the fullest extent possible [3, 4].

Dental restoration failure is a major issue in dentistry, especially in the treatment of adults. While preventive services and improved understanding of oral health have had positive effects on the DMFT index in many countries, the placement and replacement of restorations still accounts for the majority of work in general dental practise. Replacement of restorations accounts for roughly 60% of all operative work performed [5]. Failing composite restorations require careful assessment and thoughtful consideration before electing not to intervene.The major reasons for the failure of a composite restoration are operator factors or material factors.This article throws light onto frequently ignored steps of a composite restoration leading to its failure.Our research experience has prompted us in pursuing this survey [6-15].

Operator Factors

Case selection

Regrettably, the performance or failure of resin-based composite restorations is contingent on factors that the operator might not be able to manage. Restoration failure rates in patients with a high caries risk, for example, are two times higher than in patients with a low caries risk [16, 17].

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Cavity volume is the most important factor in the performance or failure of posterior composites. Large composite restorations in the posterior teeth are more likely to fail over time. In a large restoration subjected to a lot of occlusal tension, any potential for error is amplified. [17]

Isolation Failures

Moisture contamination is extremely damaging to composites. During the adhesion and bonding of composite resin to tooth structure, isolation is important. Failure to preserve separation leads to a reduction in bond strength and, as a result, a reduction in the physical and mechanical properties of the composite reconstruction. Rubber dams, gingival retraction strings, and other methods of isolation may be used. The most effective method, however, is the installation of a rubber dam. Appropriate contour and contacts are critical for composite restoration performance and longevity [18-20].

Cavity Preparation

Several studies have proven that the tensile bond strengths were higher in sound and carious affected dentin without application of caries detection dyes. Conservative structure-sparing planning methods should be used wherever possible. Traditional preparation designs, which include access through the carious marginal ridge and the removal of infected occlusal enamel and dentin, may be needed depending on the position and extent of the caries. The outer layer of deciduous enamel and 70% of permanent enamel are aprismatic, they have less mechanical retention when etched. This layer is removed by discing off 0.1 mm of enamel, which improves bond strength by 25% to 50% [21, 22].

Acid Etching

Enamel takes longer to etch because it contains more fluoride and is more difficult to etch. The end result of etching is an uneven surface that is frosty white due to light refraction.Under etching /hypocalcified enamel could result in a frosty surface not being achieved.Over-etching may result in the formation of an insoluble reaction product called monocalcium phosphate dehydrate, which prevents more etching and weakens bonding. Adult permanent teeth are etched for 20 seconds. Newly erupted permanent teeth are etched for 15 seconds and Deciduous teeth are etched between 60 –120 seconds.10 seconds is an adequate washing time. Inadequate washing results in debris that obstructs resin flow. Constant washing or three-way syringe should be avoided as a study suggests that enamel rods were crushed after 60 seconds of washing with a strong water mist, resulting in a weak resin-enamel bond.The best way to dry an etched enamel surface is with an electric hot air dryer. They have been shown to increase the strength of the enamel bond by around 29% [23-25].

Bonding

Enamel and dentin have different bonding mechanisms. Enamel contains 95% inorganic material, which is more hydrophobic. Because of the higher surface energy of the etched surface, hydrophobic bonding resins can wet and penetrate dried, etched enamel. [26-28] Dentin, on the other hand, is more hydrophilic because dentinal tubules have fluid flow, making it impossible to bind a hydrophobic resin to the dentin substrate.So, dentin surfaces have a lower bond strength than enamel.Non-uniform application of bonding agent, shift from micro-filled to macro-filled without using unfilled bonding agent in between the layers, role of evaporation, and lack of isolation effects the bonding between tooth and resin,thus leading to fracture [29-31].

Improper curing

The light should be exposed for 20 to 40 seconds. The cornerstone for photocuring has traditionally been a Quartz-Tungsten-Halogen (QTH) source, filtered to generate blue light wavelengths of between 400 and 500 nm. The best polymerization occurs at a depth of only 0.5 to 1 mm in the thickness of the composite resin. In the current market,there are various light cures and modes available [32-33]. Anshu et al. conducted a study on polymerization shrinkage and found out that for the QTH curing lamps, the soft start polymerization mode has a noticeable benefit over the usual curing process in terms of microleakage. For LED curing lamps, the soft start polymerization mode has a notable benefit over the normal curing process in terms of microleakage. Though not statistically significant, the LED light had less microleakage than the QTH lighting. As a result, as compared to the conventional curing mode, soft start polymerization results in reduced microleakage, which can help improve the marginal adaption of composite restorations Also. as the angle of light deviates from the perpendicular of the restoration, the penetration and intensity of light are affected and reduced. [34] Marginal ridges, for example, block light when placed at an angle.Any deviations in the intensity range result in a partially cured and subpar restoration. After 7 days of observation, one classic study found that a 40 second curing cycle for 1mm composite restoration thickness supplied 68 to 84 % hardness while a 3 mm composite restoration thickness gave only 34 %hardness to the restoration. As a result of this research, it was determined that composites should not be placed more than 1 to 2 mm thick in a single step [35].

Shades of Composites

Different light-curing modes and shades of methacrylate and silorane-based resin composites have various degrees of conversion of resin composites (DC). Aguiar et al.'s study showed that shade is a factor that can alter the polymerization efficacy. In this study, lighter shade showed the highest DC. Due to the opacity of dark shades, light transmission is diminished when passing through them. The photopolymerization initiation rate depends on the incident light intensity, so the reduced intensity of light led to a decrease in DC [36]. The difference could be attributed to the type and amount of dark pigments, which absorb more light and thus have fewer free radicals available for polymerization, resulting in a lower direct conversion. Furthermore, darker shades require more irradiation than lighter shades to achieve the same curing depth [32, 35].

Temperature

Preheating a composite to relatively high temperatures (54°C or 68°C) to improve flow and adaptability results in increased volumetric shrinkage. Composite shrinkage at body temperature is identical to that at room temperature [37].

Insufficient Packing

Voids occur as a result of poor packing. The presence of voids causes restoration to fail. The main causes of voids are improper mixing and insertion of composite restoration in prepared cavity, pulling of restoration during insertion, and improper condensation. Secondary caries may occur if there is a gap between the tooth and the composite [21].

Finishing and Polishing

All rough surfaces act as a niche for microorganisms, so meticulous finishing and polishing is required. Sharp projections irritate and inflame gingiva by impingement, so special care should be taken in inter-proximal areas. Dry polishing and finishing are harmful because they can open dentinal margins at the dentin-restoration interface. The damage will be reduced if you use burs with a greater number of flutes [21, 38].

When a composite is light cured, oxygen in the air interferes with polymerization, resulting in the formation of an oxygen inhibition layer on the composite's surface. The oxygen-inhibited layer is the uncured, sticky, resin-rich layer that remains on the surface. Although this layer can be removed by finishing and polishing the restoration, it is more likely to get into your bur or disc, rendering it ineffective or useless. To reduce the presence of an oxygen-inhibited layer, it has been suggested that the final cure of the composite be completed using a Mylar strip (for interproximal restorations) or a glycerin application.When glycerin is used, the final curing step is completed by the glycerin. Before finishing and polishing, the glycerin is rinsed away. As a result, the composite surface is harder and easier to finish. It should be noted that this oxygen-inhibited layer can also form on the margins of indirect restorations bonded with resin cements, so glycerin should be used on the margins of these restorations as well [21, 38-40].

Post Operative Sensitivity

Post-operative sensitivity can occur if care is not taken to avoid causes of shrinkage, bonding failure, and/or placement of composite restoration/voids, resulting in pressure changes in dentinal fluids as the flexural strength of composite restoration and tooth differs, which is transmitted to the pulp.If a deep composite restoration is not lined with $Ca(OH)_2$, it can cause pulpal pathology and irreversible damage. A resin modified glass ionomer base should be used in such cases. Zinc oxide eugenol is not recommended below composite resin because it interferes with polymerization.[41-43]

Marginal Leakage

When composite resin is applied to dentin or cementum, there is a high risk of marginal gap formation. This gap makes the restorative margin vulnerable to microleakage, secondary caries, and marginal discoloration. The passage of fluids, bacteria, or molecules between a cavity wall and the restorative material due to the presence of micrometric spaces is referred to as marginal leakage.[44] Marginal leakage is a cause of composite resin restoration failure due to a lack of adhesion, which is responsible for marginal discoloration. Marginal staining has been identified as a clinical sign of microleakage.In addition to the inherent problems associated with polymerization shrinkage, the relatively high proportion of marginal discoloration suggests inadequate acid-etching of the enamel prior to placing the resin-based composite restorations and/or inadequate fabrication of the restoration. [45] The increased etched surface area results in a stronger enamel to resin bond, which improves restoration retention and reduces marginal leakage and discoloration. The marginal staining of the restoration is also affected by proper shade selection, restoration margin finish, and the patient's oral hygiene [46-48].

Secondary Caries

Secondary caries is defined as "lesions at the margins of existing restorations." There is considerable debate about whether these lesions are caused by the presence of the dental restoration or if they are simply a new primary lesion that forms in the same region as an initial lesion that has been restored.[49] In any case, the presence or recurrence of these lesions is typically associated with the restoration's marginal areas, and it has been stated that % to 90 percent of secondary caries will be found at the gingival margin (for class II to V restorations), regardless of restorative material type. Furthermore, the initial lesion and, most likely, its recurrence are linked to patient caries risk factors. This high failure rate at these sites is most likely due to their proclivity for plaque formation, particularly in susceptible individuals, as well as the overall difficulty in cleansing it, particularly when the margin is interproximal [49, 50].

Conclusion

Composites are becoming more popular as a result of patient demand for aesthetics as well as the clinical desire to do minimal preparation and provide patients with bonded aesthetic restorations. However, composite restorations fail for a variety of reasons, and the operator should do everything possible to avoid this, from case selection to finishing and polishing. Further research is needed to reduce polymerization shrinkage and marginal leakage in order to increase the longevity of restoration and reduce the risk of failure.

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