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Review Paper

Failure in composite restoration

Vishal Mahajan [1]*, Sarvesha Bhondwe[2], Rohit Doot [3], Rupali Balpande [4], Sonam Bhandari [5], Sonali S. Dahiwale [6]

[1] Asso. Professor MDS & Guide (Department of Conservative dentistry & Endodontics
[2] Professor MDS, HOD & Guide (Department of Conservative dentistry & Endodontics
[3] Asso. Professor (MDS-Department of Conservative dentistry & Endodontics
[4] Post Graduate Student of Department of Conservative dentistry & Endodontics Y.C.M.M. & R.D.F.Ahmadnagar
[5] Senior Lecturer MDS-Department of conservative dentistry & Endodontics
[6] Asso. Professor MDS-Department of Prosthetic Dentistry G.D.C. Aurangabad
**Corresponding author E-mail: rupalibalpande@gmail.com*

Abstract

In recent years, the popularity of tooth colored restorative material has led to a rapid increase in the use of resins. This critical review paper is meant to be useful contribution to the recognition & understanding of problems related to the failures of composite restoration. This review categorizes the challenges as those related to the restorative materials, the dentist and the patients. In spite of the major improvements in both physical and mechanical characteristics following factors are still of major concern, such as improper case selection, isolation, wear resistance, cavity preparation, placement of composites, curing, finishing & polishing. Major problems associated with composites failures are polymerization shrinkage & contraction stress related to polymerization shrinkage, water sorption, solubility, discoloration of restoration (staining), elution of material from restoration, marginal failures, secondary caries, and fracture of the restoration, post-operative sensitivity, and micro-leakage.

Keywords: *Composites Failures; Microleakage; Polymerization Shrinkage; Postoperative Sensitivity; Staining and Discoloration*

1. Introduction

Composite Resins have been used for nearly 50 years and year after year improvements have been made regarding their composition and their handling properties. Since 1990, many classifications of resin composites have been introduced. Most of them differed mainly in the particular filler system used, e.g. conventional / traditional, small particle composites, hybrids (micro hybrid, monohybrid, submicron hybrid & nanohybrid) (Joseph Sabhagh 2009). The incorporation of the filler in the composite material has enhanced the mechanical properties of the composite such as compressive & tensile strength, surface hardness or resistance to surface indentation (Albers HF 2002).

Composites are indicated in both anterior & posterior esthetic purposes. However, there are problems, which are limited the use of composites, especially in posterior teeth. So evenif composites have become one of the most preferred esthetic restorations in modern times. But as they say.

"All that looks gold is not gold, even these restoration have its own drawbacks".

Failures that can be seen in a composite restoration are as follows:-

2. Improper case selection –

Composites are the material used both in anterior and posterior teeth restoration. They are indicated in class III, IV & V lesion in anterior teeth & small to moderate class I & II cavities (Albers HF 2002).

Failure in case selection is done, in case with poor oral hygiene as composite resin attaches greater level of pathogenic bacteria than amalgam restoration, which may lead to secondary caries due to microleakage (Bohaty BS et al. 2013).

Occlusion – Occlusal contacts on enamel may be considered desirable and, ideally all cavity margins should be in enamel. Composite resin has less wear resistance hence patient with heavy occlusion such as bruxism or restoration , that provide all the tooth contacts of antagonist may lead to the failure of the restoration (Bohaty BS et al.2013, Cavalcanti AN et al. 2007).

So a pretreatment assistant of occlusion with articulating paper is done to guide the practitioner in preparation design (Brian Kenyon et al. 2010).

3. Operator's factor

3.1. Lack of isolation

Composites are very sensitive to moisture contamination. Isolation is very mandatory during adhesion and bonding of composite resin to tooth structure. Fail to maintain isolation causes decreased bond strength & ultimately physical & mechanical properties of composite restoration have also decreased (Hickel R 2001).

3.2. Incorrect placement of rubber dam

Isolation can be done with rubber dam, gingival retraction cords etc. But the most important procedure is placement of rubber dam. Appropriate contour and contacts are important for success & longevity of composite restoration. It is achieved by proper placement of rubber dam (Bohaty BS ET al.2013, Hickel R 2001, Theodore M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication, N Ilie et al. 2011). Matrix

should be rigid enough when packable restorative material used. It can be flexible when used for anterior restoration.
Matrix system should provide appropriate contour and contact that prevent overhangs (Bohaty BS et al. 2013). The matrix band should be burnished to have appropriate contour of desire shape to prevent open contact. If in anterior teeth it happens, it may provide unaesthetic restoration & for posterior there might be food impaction, pain & subsequent perio-problems. Matrix band should be 1mm above the adjacent tooth (Theodore M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication). Wedges are applied in the area of gingival embrasure to provide proper contour and contact, to prevent gingival overhangs & to hold matrix band in place (Bohaty BS et al. 2013, Theodore M. Robinson 2006 Sturdevants- Art and Science Of Operative Dentistry. Elsevier publication).

3.3. Incorrect manipulation

i) Acid etching
Etching time-
15-20 sec - On permanent tooth
60 sec - On primary tooth, as it is more amorphous & does not form the deep resin tags.
Enamel require more etching time as fluoride content is more & it is resistant to etch, The end results of etching that it appears as irregular surface and frosty white owing to light refraction (Henry Wadsworth Longfellow 2002 Albers-Resin Polymerization,BC Decker Inc Hamilton. London).
ii) Acid Strength
Buonocore used 85% phosphoric acid first. But later studies said higher concentration are less effective & are more likely to denude surface, so research suggest 37% phosphoric acid is the ideal concentration (Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London) .Care should be taken that acid should replenish before use as it evaporates during storage.
i) Under etching
Failure to achieve a frosty surface could results from under etching / hypocalcified enamel (Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).
ii) Over etching
Can cause an insoluble reaction product monocalcium phosphate dehydrate which prevents further etching and causes weak bonding (Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).
Average time
Adult permanent 20 sec newly erupted Permanent15 sec Deciduous 60 – 120 sec
Washing time - 10 sec
Insufficient washing leaves debris that interferes with the flow of resin. 60 sec washing with heavy water spray actually weak resin-enamel bond as enamel rod crushed (Henry Wadsworth Longfellow 2002 Albers-Resin Polymerization .BC Decker Inc Hamilton. London, Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).
Drying
Electric hot air dryers are the best way to dry an etched enamel surface. They have shown to improve enamel bond strength by about 29%.
The least desirable is three way syringe / liquid drying (Henry Wadsworth Longfellow 2002 Albers-Resin Polymerization .BC Decker Inc Hamilton. London, Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).
Type of etching material
For pits & tissues, liquid is recommended.
For smooth surface etching, liquids & gels results in similar etch patterns (Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).

3.4. Improper cavity preparation

Cavity preparation for composite is as conservatively as possible. Outer layer of enamel of deciduous & 70% enamel of permanent teeth is aprismatic, so provide less mechanical retention when etched. Disking off 0.1 mm of enamel removes this layer & improves bond strength by 25 to 50% (M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication, V. Ritter et al. 2008, John Kennedy 2002 Albers- Tooth-colored Restoratives,principles and techniques, BC Decker Inc Hamilton.London).

3.5. Role of exit angle

90^0 exit angle is conservative but doesn't expose the enamel rods. 45^0 exit angle form most common superior seal with decreased microleakage & exposed rods. Concave exit most retentive but least conservative which is used in class IV cases. Larger preparations extended into dentin may require additional beveling to facilitate better sealing & bonding (Theodore M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication, John Kennedy 2002 Albers- Tooth-colored Restoratives,principles and techniques, BC Decker Inc Hamilton.London).

3.6. Improper bonding

Bonding mechanism of enamel and dentin differs. The inorganic component of enamel is 95% and is more hydrophobic. So hydrophobic bonding resins can wet & penetrate dried, etched enamel because of higher surface energy of etched surface. But contrary to that dentin is more hydrophilic as dentinal tubules have fluid flow, which makes bonding a hydrophobic resin into the dentin substrate difficult. Bond strength to all dentin surfaces is lower than to enamel (Bohaty BS et al. 2013, Harry F 2002 Albers Resin Bonding Marconi BC Decker Inc Hamilton. London).
The bonding between tooth & resin may fracture because of following reasons:
i) Non-uniform application of bonding agent.
ii) Shift from microfilled to macrofilled without using unfilled bonding agent in between the layer.
iii) Role of evaporation (Mansi AP et al. 2008).
iv) Lack of isolation.

3.7. Improper angle & path of light

As angle of light deviates from perpendicular direction, the penetration & intensity of light is affected & reduced. e.g. Marginal ridges blocks the light placed at an angle.[11,] Optimum polymerization occurs at depth of just 0.5 to 1 mm of thickness of composite resin (Joseph Sabhagh 2009, Henry Wadsworth Longfellow 2002 Albers- Resin Polymerization .BC Decker Inc Hamilton. London, Garry J.P. Fleming et al . 2008).
One classical study after 7 days observation showed that, 40 sec curing cycle for 1mm thickness of composite restoration gave 68 to 84% hardness and 3 mm composite restoration thickness gave 34% of hardness to the restoration. So from this study, concluded that composites should not be placed more than 1 to 2mm in thickness in single increment.

3.8. Color of composite

Darker shade cures slowly & less deeply than lighter shades.

3.9. Type of filler

Microfilled composites are more difficult to cure than macrofilled composites.

3.10. Air inhabitation

Oxygen in air competes with polymerization & inhibits setting of resin. So unfilled should be cured & covered with air inhibiting gel-oxyguard commercial preparation (Henry Wadsworth Long-

fellow 2002 Albers- Resin Polymerization .BC Decker Inc Hamilton. London). Apply Petroleum gelly /glycerin & then recurred. This reduces air inhabitation.

3.11. Improper light intensity

Optimum curing intensity – 468 + 20 mm
Causes of decreased intensity,
i) Age of bulb
ii) Voltage
iii) Sterilization of curing tips reduces light transmission.
iv) Filter to increase blue light transmission.
Exposure of light should of 20 to 40 sec. Any deviations in intensity range results in partially cured and inferior restoration (Henry Wadsworth Longfellow 2002 Albers- Resin Polymerization .BC Decker Inc Hamilton. London)

3.12. Temperature

Light cure composites are less effective if they are cold during application. Heat accelerates polymerization but excess heat & undue pressure results in pulpal irritation & inflammation (Henry Wadsworth Longfellow 2002 Albers- Resin Polymerization .BC Decker Inc Hamilton. London)

3.13. Inadequate pulp protection

Deep composite restoration may lead to pulpal pathology & irreversible damage if not lined with Ca $(OH)_2$. In such cases, resin modified glass ionomer base should be used. Zinc oxide eugenol is contraindicated below composite resin as it interferes with polymerization (Theodore M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication)

3.14. Voids

It leads to failure of restoration. Causes of voids are mainly improper mixing and insertion composite restoration in prepared cavity, pulling of restoration during insertion, improper condensation .Void between tooth and composite may results in recurrent caries (Bohaty BS et al. 2013, Opdam NJ , et al 1996).

3.15. Inadequate finishing & polishing

Meticulous finishing & polishing is to be done, as all rough surfaces acts as nidus for microorganisms. Special attention in interproximal areas should be given as sharp projections irritates & inflames gingiva by impingement. Dry polishing & finishing is detrimental as it can open dentinal margins at dentin-restoration interface. Using the burs having more number of flutes, lesser will be the damage (Theodore M. Robinson 2006 Sturdevants- Art and Science of Operative Dentistry. Elsevier publication, Vince Lombardi 2002 Tooth-colored Restoratives, principles and techniques, BC Decker IncHamilton, London

3.16. Cytotoxicity studies states

Cured polymerized resins as far as possible cause minimum irritation than incompletely cured resins. E.g. HEMA which is highly hydrophilic & allergic causes deleterious effect to pulp by transfusing through dentinal tubules.

4. Failures due to inherent properties of the material

4.1. Polymerization shrinkage & stresses due to polymerization

Composite shrinks immediately upon setting (2-3% by volume) as matrix monomer convert to polymer. On shrinking stresses are invariably generated within the material at the margins (Henry Wadsworth Longfellow 2002 Albers- Resin Polymerization .BC Decker Inc Hamilton. London). Larger the increment of composite, greater the total shrinkage, this will again increases the potential for stress formation (Bohaty BS et al. 2013) other factors are,

i) C-factor -It is the ratio of bonded surface to unbonded tooth preparation (V. Ritter 2008, Manso AP 2008). Increase C- factor increases the polymerization shrinkage. Increase free surface (unbonded surfaces) more the favorable situation.
ii) Cavity volume
iii) The amount and quality of residual mineralized tooth tissue
iv) Location of cavity margins (John Kennedy 2002 Albers-Tooth-colored Restoratives, principles and techniques, BC Decker Inc Hamilton. London)
v) Bond strength of adhesive (Bohaty BS et al. 2013)
vi) Material composition – e.g. more the filler particles less will be the shrinkage (Albers HF 2002, Tooth-coloured Restoratives, principles and techniques, BC Decker Inc Hamilton, London, Combe E & Burke F 2000).
vii) Curing characteristics

Consequences of polymerization shrinkage

i) Polymerization occurs towards the walls where composite is strongly bonded. Separation may occur at the interface. Partial or total bond failure may results in loss of the restoration.
ii) Post-operative sensitivity (Bohaty BS et al. 2013).
iii) Marginal gap formation (Yap AU 2003).
iv) Ingress of bacteria and secondary caries (Bohaty BS et al. 2013).
v) The contraction forces transmitted to enamel and dentin, causing cusp flexure, fracture or crazing of enamel and fracture in composite material (Kinomoto Y et al. 2000).

4.2. Water sorption

Incompletely cured resin will exhibit more water sorption. It has been seen that due to water sorption there is swelling of composite resin and the bonding strength of restoration decreases. It can be minimize by increasing filler content (Sideridou ID et al. 2007)

4.3. Solubility

Leaching of composite components seen more in case of incomplete cured composites (Garry Fleming et al 2008, Ferracane J 1994).

4.4. Wear of composites

Many of researches have been done related to wear pattern of different composites. Each composite have differed amount of wearing resistance (Yong-Keun et al. 2007). But it is found that any composite wear more than enamel. Microfilled composite even the particles are extremely small the inner spacing is less, so good food abrasion wear resistance (Leinfelder KF 1987) .Narrow preparation minimizes bolus contact and increases wear resistance which is called Macro-protections (Albers HF 2002). If tooth preparation is wide or located at posterior (molar) tooth, the restoration is more susceptible to wear. (V. Ritter 2008).

5. Improper storage of composite resin material

i) Affect bond strength
ii) Premature failure

6. Staining & discoloration

Surface staining & discoloration are an inherent drawback of composite restoration (S. Kubo et al. 2004). Causes of staining might be following media such as coffee, tea, red wine, cola etc.

7. Post-operative sensitivity

If care not taking to avoid causes of shrinkage, bonding failure and / or placement of composite restoration, post-operative sensitivity can arises.

Causes;

i) Gap created between restoration & tooth surfaces (V. Ritter 2008).
ii) Pressure changes in dentinal fluids as flexural strength of composite restoration and tooth differs which transmitted to the pulp.

8. Marginal failure

Composite have poor marginal strength (Ryan Francisco Alberto et al. 2007). So margins of restoration should away from the occlusal contact points. If margins left open there may be chances of microleakage resulting in formation of secondary caries (V. Ritter 2008).

9. Secondary caries

Main cause of secondary caries is micro leakage and cause for replacement of composite restoration is secondary caries (Bohaty BS et al. 2013, V. Ritter 2008).

10. Fracture of restoration

Composite shows bulk fracture but marginal fracture are more common (Joseph Sabhagh 2009).

11. Microleakage

Microleakage causes post-operative sensitivity and invasion of bacteria e.g Streptococcus mutans. Microleakage results in subsequence inflammatory changes, secondary caries & discoloration of restoration[11]. Marginal gaps are primarily results from polymerization shrinkage on setting of resins (S. Kubo et al. 2004). After setting, dimensional changes occurs by masticatory forces, thermal changes & water sorption of composite restoration (V. Ritter 2008, Lim BS 2002). Hybrid and packable resin composites exhibited significantly more leakage than either the flowable or the microfilled composites (Lim BS 2002, Sikri VK 2002 Textbook of Operative Dentistry CBC Publishers & Distibutors).

12. Modulus of elasticity

Modulus of elasticity of composites is less than enamel (33.6 GPa) & dentin (11.7 GPa) that is (10.5 GPa), so composite forms weak bonds & tends to have micro movement under stress which causes bond failure (N Ilie et al. 2011, Braem M et al.1986).

13. Conclusions

Posterior composites can be used with maximum longevity when cases are well selected. This brief article reviews some keys aspects of the failures and methods to overcome them. The two main causes of composite restoration failure are secondary caries and fracture. A review and update of composite restoration in terms of preparation design, matrix choice, and resin system demonstrate the limited extent to which these factors influence the overall clinical lifetime of resins

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