Review Article

POLYMERIZATION OF COMPOSITE AND ASSOCIATED FACTORS

Abhinay Agarwal[1] ,Payal Kundgulwar[2] ,Atul jain[3] ,Rohit Sharma[4],Mohd.abbas ansari[5] ,Raj kumari victoria[6]

Professor[1,4]Post Graduate[2,5,6] Professor & Head[3]

1-6- Department of Conservative Dentistry and Endodontics,Teerthanker Mahaveer Dental College and Research Centre, Moradabad, Uttar Pradesh, India

Abstract

Composites have become the mainstay of restorations these days. Due to its technique sensitivity, proper handling of material, cavity design, operating field influences the longevity of restoration. Polymerization is one of the major topic of concern regarding the use of composite. Therefore, factors influencing the polymerization and method to overcome should be considered while using composite resin.

INTRODUCTION

In the era of restorative dentistry, gold alloy was preferred as the first choices for restorative procedure. With the time various materials were introduced in the field of dentistry. With a declining acceptance of amalgam among patients, current trend shifted from metallic amalgam to resin-based cements. Composite resins materials have been introduced in the dentistry to minimalize the shortcomings of the acrylic resins which replaced silicate cements. (1) Composite material is thermally and electrically inert, without mercury, and, non-metallic with the property of bonding to the hard tooth tissue directly , and confirms a worthy aesthetic appearance of a natural tooth. Bond between tooth-composite is the key factor governing the longevity of these restorations. Composites are pliable to minimally invasive or noninvasive managements associated with consistent clinical performance and favorable properties. Even though composite has many advantages, drawbacks are also associated with these materials. Polymerization shrinkage stress has been widely referring to as one of the most challenging property [2] which are primarily influenced by cavity outline and volume, composite resin material properties and placement technique. This article is an attempt to discuss the various factors that influence the polymerization of composite, leading to development of contraction stresses in dental composites and methods to overcome them.

Polymerization mechanism

The dental composite undergoes a chemical reaction between dimethacylate resin monomers. This results in formation of a rigid and cross-linked polymer network surrounding the filler particles. Complete polymerization of the material is determined by the degree of conversion of monomers into polymers which is indicative of the number of methacrylate groups that have reacted with each other during the process of conversion . A polymer chain buildup take place by two distinct polymerization mechanisms either step or chain growth polymerizations. Their mechanisms vary in the types of monomers involved, and on the stages of polymerization at which the development of high molecular weight species is detected. Some monomers will undergo polymerization with any reactive species, while others show high selectivity toward ionic (anionic or cationic) or radical initiator.

In general, chain polymerization occurs in three phases: initiation, propagation, and termination.

1. Initiation: The reactive centers are produced by activation of thermal, photoactive or redox mechanism. Then the reactive centers will react with the monomer molecule , and the breaking of carbon double bonds takes place ,which leads to the macroradical formation .

2. Propagation : The reactive center is uninterruptedly transmitted between the monomer molecules, also each monomer molecule in addition produces a new reactive center. The polymer chain propagates in high speed.

3.Termination: In this process, reactive centers are destroyed (by combination of macroradicals or disproportionation reactions), and the addition of new monomer molecules is limited .

In step-growth polymerizations, (in case of linear polymers) the molecular weight or the polymer network (in the case of cross-linked polymers) does not develop until there is very high degrees of conversion. Here ,the reaction proceeds between two different functional groups, whether they are on the same molecule or different molecules.

Factors affecting polymerization of resin

Factors affecting polymerization	
Incident light	An intensity greater than 400 mW / cm^2 , allowing a reduction of the exposure time is recommended in order to polymerize the composite optimally.
Shade of resin material	Darker composite shades cure slowly and less deeply compared to lighter shades .
Disinfectants and other additives	when chlorhexidine is used as disinfectant there is loss of hybrid layer integrity which compromises resin-dentin bond stability
Temperature	Composites at a higher temperature reduce their viscosity and increase the efficacy of polymerization
Type of filler	The smaller the size of the filler particles, the higher the light scattering occurs.
resin thickness	Optimal thickness (1-2 mm)
Light tip coverings	The reduction in output of light was observed up to 70.5% when latex gloves were used covering the curing tips and 1.6% when a cellophane wrap used.
Light source quality	Wavelength of light soure between 400 to 500 nm. A power density of 600 mW /cm2 is required to confirm that 400 mW/ cm^2 reaches the first increment of composite .
Distance between light curing unit and resin	Minimum distance of < 1 mm, with the light tip positioned 90 ^{0} from the composite surface
Angulation of Light Tip	The tip of the light curing unit should be parallel to the restoration surface to reach maximal light intensity at the surface.

Many factors affect the polymerization of composite such as the shade, duration of light curing, thickness of increment , light curing unit system used, diameter of cavity, location of cavity, distance between light curing tip and the restoring surface, substrate through which the light is cured for example, curing through ceramic, enamel, or dentin), filler type, and temperature. (1)

Polymerization shrinkage stress Despite various developments in restorative materials over the last years, shortcomings related to polymerization shrinkage of composite resin cements remain a clinical problem. Composite materials used in restorative procedures show volumetric shrinkage ranging from 1% to 6%, depending on the curing conditions and formulation. (11) Shrinkage stress of resin-based materials may lead to cusp deflection, enamel crack propagation, marginal and internal gaps formation, and decreased bond strength. (3)

Factors affecting polymerization shrinkage stress:

1. Composite insertion technique- Restoring a city in oblique increments results in a smaller amount of cuspal flexure compared to a single increment based on tests carried out with aluminum blocks. (4) This concept is based on a theory that the ratio of bonded and unbonded restoration surfaces i.e.C-factor determines the shrinkage stress.

2. Modifying the light-activation protocol- Use of techniques to control the light-activation are based on the theory that delaying the composite vitrification allows more release of shrinkage stress by extending the period that composite can flow. For soft-start curing, the light-activation begins with a low irradiance for about 10 seconds followed by increased irradiance for the residual period of light-activation to complete the process of polymerization . (5)

3. Stress absorbing intermediate layer- using a material with low elastic modulus as an intermediate layer under the composite can minimise the shrinkage stress in a concept called ‘elastic cavity walls’. (12) Several studies have evaluated the use of glass ionomer , thicker adhesive layers (usually non-solvated adhesives), or flowable composites as a stress absorbing layer. (6)

DISCUSSION

With the invention of composite materials almost 60 years back, these materials have come a long way and have observed lot of changes both in their development and also in acceptance in minds among dentists. In the oral cavity, restorations are subjected to stresses from mastication. These forces act on teeth as well as material producing different reactions that lead to deformation, which can eventually compromise the durability of restoration over time. (7) Adequate physical properties of light cured dental composite resins are achieved when the Light Curing Unit deliver an adequate amount of light at the appropriate wavelength of the respective photoinitiator systems in the composite resins . The polymerization of light cured dental composite resins depends on the power densities and wavelength of light curing unit. Many studies found that the LCUs based on LED seems to be the finest option. (8) Correr et al. found that increasing energy densities for LED and xenon plasma arc increased the MH of two different resins, but that there was no significant difference when the halogen light-curing unit was used with different intensities. [9] Kim et al. (2002) studied the relation between filler ontent and flexural properties and found that the composites with the highest filler content presented the highest flexural strength, flexural modulus and hardness, the maximum fracture toughness was obtained at approximately 55% of filler volume. (10) The type of inorganic particle content and the composition of the resin matrix influence the property of the mechanical resistance of composites.

CONCLUSION

Despite of intense research on bonding mechanisms between the dental tissue and the composites, clinical failure of the bonded interface remains a frequent occurrence. Interfacial defects may develop as a result of long-term mechanical as well as thermal stresses. They may develop while doing the restorative procedure, or due to stresses generated by polymerization shrinkage of composite. Future research will be focused on the development of non-shrinking polymer systems which can be mixed with suitable curing modifiers and fillers to produce restorative materials with excellent qualities. It should be considered that they are highly technique-sensitive, therefore control over certain factors such as good isolation, correct indication, correct choice of the composite, use of correct procedure for bonding as well as curing gives satisfactory clinical results.

REFERENCES

1. Hervás-García A, Martínez-Lozano MA, Cabanes-Vila J, Barjau-Escribano A, Fos-Galve P. Composite resins. A review of the materials and clinical indications. Med Oral Patol Oral Cir Bucal 2006;11:E215-20.
2. Ferracane JL. Developing a more complete understanding of stresses produced in dental composites during polymerization. Dent Mater. 2005;21(1):36–42.
3. Carlos J. André Luis F et al. Polymerization shrinkage stress of composite resins and resin cements – What do we need to know. Braz. Oral Res. 2017;31(suppl): e62.
4. Park J, Chang J, FerracaneJ, Lee IB. How should composite be layered to reduce shrinkage stress: incremental or bulk filling? Dent Mater. 2008;24(11):1501-5.
5. Tauböck TT, Feilzer AJ, Buchalla W, Kleverlaan CJ, Krejci I, Attin T. Effect of modulated photo-activation on polymerization shrinkage behavior of dental restorative resin composites. Eur J Oral Sci. 2014;122(4):293-302.
6. Cara RR, Fleming GJ, Palin WM, Walmsley AD, Burke FJ. Cuspal deflection and microleakage in premolar teeth restored with resin-based composites with and without an intermediary flowable layer. J Dent. 2007;35(6):482-9..
7. Reid CN, Fisher J, Jacobsen PH. Fatigue and wear of dental materials. J Dent 1990;18:209-15.
8. Antonson SA, Antonson DE, Hardigan PC. Should my new curing light be an LED? Oper Dent. 2008;33(4):400-7.
9. Correr AB, Sinhoreti MA, Sobrinho LC, Tango RN, Schneider LF, Consani S. Effect of the increase of energy density on Knoop hardness of dental composites light-cured by conventional QTH, LED and Xenon Plasma arc. Braz Dent J 2005;16:218-24.
10. Kim K-H, Ong JL, Okuno O. The effect of filler loading and morphology on the mechanical properties of contemporary composites. J Prosthet Dent 2002;87:642-9.
11. Rosatto CM, Bicalho AA, Veríssimo C, Bragança GF, Rodrigues MP, Tantbirojn D, et al. Mechanical properties, shrinkage stress, cuspal strain and fracture resistance of molars restored with bulk-fill composites and incremental filling technique. J Dent. 2015;43(12):1519-28.
12. Soares , Carlos José et al. Polymerization shrinkage stress of composite resins and resin cements – What do we need to know?. Braz. oral res. . 2017, vol.31.

Corresponding author
Dr. Payal Kundgulwar
Post Graduate
Department of Conservative Dentistry and Endodontics, Teerthanker Mahaveer Dental College and Research Centre, Moradabad, Uttar Pradesh, India
Email Id: payalkundgulwar@gmail.com
Contact No. 7758868673

How to cite this article: Agarwal A, Kundgulwar P, jain A, Sharma R, Ansari M, Victoria R. Polymerization of composite and associated factors. TMU J Dent 2020;7(2):38-40.