FILLERS IN COMPOSITE RESINS- RECENT ADVANCES

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ABSTRACT:

Composite restorative materials represent one of the many successes of modern biomaterials research, since they replace biological tissue in both appearance and function. At least half of posterior direct restoration placements now rely on composite materials . Composite resins are a class of dental restorative materials that are a mixture of organic and inorganic components. The primary organic components are the resin, the coupling agent, the initiator and filler. Fillers play a pivotal role in the performance of composite resins. Fillers can be from a wide range of materials. Fillers in composites can be made of glasses, ceramics, metals etc. Glass fillers are usually made of crystalline silica, silicone dioxide, lithium/barium-aluminium glass, and borosilicate glass containing zinc/strontium/lithium. Ceramic fillers are made of zirconia-silica, or zirconium oxide. The development and implementation of composite dental restorative materials rely on a comprehensive understanding of each component of the composite and consideration of methods for changing each component. The aim of the review is to showcase the recent advances in composite resin fillers which have substantially improved the clinical performance of composite.

KEY WORDS: Composite resin, Fillers, Nano fillers ,Recent advancements, Silane treated fillers , Sol gel fillers .

INTRODUCTION:

We are living in an era of esthetic dentistry where Amalgam is increasingly being replaced by aesthetic restorative materials, whose colour mimics that of natural tooth. Composite resins that can be cured using visible light are the most widely used for direct aesthetic restoration. The main composition of composite is the inorganic filler, which gives rigidity, hardness and strength to the filling, and an organic resin matrix, which provides sufficient fluidity for easy application of the composite , and allows polymerisation for rapid setting of the composite resin . In Composite resins, significant improvements have been made in their microstructure and properties. To reinforce dental composite resins, short glass fibers have been used as fillers,producing limited improvements in composite mechanical properties (Xu, 1999) . Currently available direct-filing composite resins are susceptible to fracture and hence are not recommended for use in large stress-bearing posterior restorations involving cusps.The glass fillers in composites provide only limited reinforcement because of the brittleness and low strength of glass (Masouras, Silikas and Watts, 2008) .

The composite resin filler size is only one of several parameters affecting the overall properties. The filler type, shape and amount, as well as the efficient coupling of fillers and resin matrix, contribute to the material performance (Khan *et al.*, 1992) . The combination of relatively small and varied size fillers allows a more dense packing, which in turn increases the possible filler volume-fraction of the resin-composites. Moreover, the spherical shape, especially in a mixture of different sizes, different geometrical forms facilitates incorporation of more inorganic fillers in the resin matrix . It also improves the fracture strength of the materials because stresses tend to develop preferably at sharp edges of the fillers (PradeepKumar *et al.*, 2016) .

Attrition, humidity and mastication forces contribute to wear and bulk fracture, in which the filler of the composite plays a major role. The amount of wear is directly proportional to the size and hardness of the filler particles (Schneider, Cavalcante and Silikas, 2010) . Leakage of filler elements from the composite may cause the crack formation in the composite through the hydrolytic degradation of the silane coupling layer and may induce the adverse effect on the oral soft tissue (Ramamoorthi, Nivedhitha and Divyanand, 2015) .The manipulation of the composite is also strongly influenced by the filler. For instance, the composites containing smaller (e.g. microfilled) filler particles are easier to pack and polish, compared to the composites containing larger (e.g. conventional size) filler particles (Klapdohr and Moszner, 2005) . On the other hand, the former is inferior to the latter with regard to mechanical properties such as the compressive strength (Ramanathan and Solete, 2015) .

Particulate inorganic fillers are used in dental resin composites to provide material strengthening and reinforcement . Several types, shapes, sizes, volume fractions, and distributions of filler particles are used in commercial products and all these factors affect the material's properties, such as hardness, thermal stability , radio-opacity ,gloss retention and roughness , water sorption; viscoelastic creep and recovery , fracture toughness , fracture behaviour ,elastic moduli (Xu *et al.*, 2009) . The total volume of fillers used in the resin-composite formulations may vary a lot in volume according to the clinical applications, companies' fabrication processes, and the resin matrix viscosity. The composition of fillers may also vary among the different brands in the market and can be quartz, silica, zirconium, strontium, barium, and others.[(Fu *et al.*, 2008)]

Functionalized inorganic clusters used as new additives in composite resin are well designed for monomers with high cross linking capabilities (R, Rajakeerthi and Ms, 2019) . Low viscosity affects the preparation of composites with a high filler load, thus reducing the shrinkage of the composite resin during polymerisation and improves the mechanical properties(Rajendran *et al.*, 2019) .

RECENT DEVELOPMENTS :

Most current research efforts in the field of dental composite resins are directed towards reducing polymerisation shrinkage. Other important goals are improving the biocompatibility and the mechanical properties of the composite resins. These are the problems which led the development of improved composite resins.

FILLER MODIFICATIONS:

Dental resins is an important family of biomaterials that have been developing to the needs of biocompatibility and mechanical properties of biomaterials. They are composite materials consisting of mostly inorganic fillers and additives bound together with a polymer matrix (Aguiar *et al.*, 2012) .A large number of fillers in a variety of forms (spheroidal, fibrous, porous, etc.) along with other additives have been studied to enhance the performance of the composites (Siddique *et al.*, 2019). Silane derived materials are attached as coupling agents to the fillers to improve the interfacial properties of the composite resin . A dental composite filler seems to suggest that every one type of filler has its own strengths and weaknesses, so combinations of these fillers will improve the resin composites with the desired properties (Nasim *et al.*, 2018) .

For fillers , additives such as nanotubes, whiskers, fibers, and nanoclusters have been shown to improves the properties of these hybrid materials, and their use in small fractions may improves the overall performance of the dental composite resin materials (Kumar and Delphine Priscilla Antony, 2018) .The filler in composite resin constitutes a large potential source of improvement in composite - based dental restoratives (Ravinthar and Jayalakshmi, 2018) . A significant fraction of the practically implemented improvement in composites in recent decades has occurred in the nature, type, size distribution and surface modifications of the filler (Cramer, Stansbury and Bowman, 2011) . The recent approaches that involve the implementation of advances in filler technology that results in improved composite restoration (Noor, S Syed Shihaab and Pradeep, 2016) .

NANOFILLERS IN DENTAL COMPOSITE :

Nowadays a significant development has been seen in nanofilled materials, including improvements realized by incorporation of nanofillers into composite resin and nano sized fillers can be categorised as either isolated discrete particles with dimensions of approximately 5 to 100nm or fused aggregates of primary nanoparticles, where the cluster size may significantly exceed 100 nm (Rezvani *et al.*, 2016) . This improvement done in fillers, optimizes the surface area and the corresponding thickening effect on composite resin paste consistency associated with decreasing filler size and low loading levels, whereas high contents of nanoparticle clusters are manageable with appropriate surface treatment (Ramesh, Teja and Priya, 2018) .

High performance composites are developed by using nano filler (Wilson *et al.*, 2007). The incorporation of silica nanoparticles had significant positive effect on the flexural strength and mechanical improvement is increased by incorporation of various nanoparticles . The effect of filler on flexural strength is increased by nanofillers . High content of SiO2 nanoparticles was advantageous in bond strength between fibres and resin matrix (Janani, Palanivelu and Sandhya, 2020) .

SOL GEL DERIVED FILLERS :

Sol gel derived materials used as filler in dental composite resin offers a flexural strength for filling material (Owens *et al.*, 2016). It offers a wide range of nano microstructures and provides excellent bio active composite resins (Alkhudhairy, 2017) . The sol gel synthetic approach was used to produce nearly monodisperse silica particles of adjustable size from 5 to 450 nm . Silanization conditions were identified that yielded uniform surface coverage regardless of particle size, and dental composites were formulated by incorporation of the nanoparticles alone or in combination with a barium glass filler so that particle dispersion and resin/filler adhesion potential could be examined (Jose and Subbaiyan, 2020). A good dispersion of the sol gel derived fillers in the composite was demonstrated, along with a significant increase in flexural strength compared with that of the unaltered composite material (Teja and Ramesh, 2019) .

CARBON NANOTUBULAR FILLERS :

Carbon nanotubes are of great interest for use in polymer composite as these fillers have unique properties such as high electrical and thermal conductivity which helps in increasing the ultra high mechanical strength with high ratio of nano sized values in diameter of filler (Mamunya, 2011) . The carbon nanotube fibre is marketed as dura fillers which is esthetic ,photo curable and it increases the flexural strength compared to unaltered composite filler (Manohar and Sharma, 2018) .The mechanical properties of the dental composite is increased by the combination nanoparticle containing (Vallittu, 2015) .

MESOPOROUS SILICA FILLERS :

The mesoporous silica fillers has properties of eliminating the silate mediated interface between fillers and matrix while providing a potentially more stable direct mechanical interlocking (Jin *et al.*, 2008) . Mesoporous filler silica particles are porous structures as well as non porous (Yang *et al.*, 2016) . Silica filler shows that optimal filler loading and mechanical reinforcement were achieved with a mixture of the filler (Samuel *et al.*, 2009) .

Wrinkled mesoporous silica particle exhibit better reinforcement effect in dental composite than regular silica using in composite resin (Nandakumar and Nasim, 2018)].Porous fillers are considered as an effective way to improve mechanical properties of dental composite through the inter locking with organic matrix(Emami, Sjödahl and Söderholm, 2005) . Mesoporous SiO2 filled composites exhibit higher transparency, higher glass transition temperature and higher adhesive strength, which makes mesoporous SiO2 a promising filler for anterior composites .(Wang, Habib and Zhu, 2017) .

SILANE TREATED FILLERS :

The surface modification of most fillers used in dental composites is necessary to reduce the filler surface energy such that composite resin consistency and hydrophilicity are reduced, while filler dispersion within the resin is enhanced and to provide a functional interface that permits covalent bond between the polymer matrix and the reinforced filler (Aydınoğlu and Yoruç, 2017) . Filler shape modification and surface modification relative to the resin produce the effects of the filler on the composite properties. (Nunes, Pereira and Kalachandra, 2008) .

A silane-mediated bonding between a resin composite cement and silica-coated titanium evaluated the efficacy of a variety of functional silanes, including several lacking methacrylate-reactive sites. The results verified the advantage of MPS and its acrylate analog but also pointed out the potential of a mercapto functionalized silane to serve as a durable coupling agent (Matinlinna, Lassila and Vallittu, 2007) . The effect of the applied filler surface on the handling properties of uncurled composite paste as well as the photo polymerisation process and the final composite properties were investigated (Sideridou and Karabela, 2009). There is no significant difference in conversion of composite prepared with silica nanoparticles treated with other materials (Bijelic-Donova *et al.*, 2016). The structures of various silane modified fillers are surface treated and short-fiber fillers based on ultra-high-molecular-weight polyethylene improves the composite resin toughness, due to the formation of a ductile interface however composite strength and modulus were compromised (Attik *et al.*, 2017).

LIMITATIONS :

For this review, the computational and quantitative data are not much available and more research is required for fillers in composite resin.

CONCLUSION :

This review explains inorganic fillers, nanofillers materials incorporated composite resin , mesoporous silica fillers , silane treated filler and it's properties , advantages and disadvantages . There are many rooms for improvement and further development of fillers in dental composite resins which can enhance life, performance and esthetics of restorations. Future research can lead to development of resins with novel fillers which can lead to the development of the most ideal esthetic dental restorative material.

CONFLICT OF INTEREST: No conflict of interest

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