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Review Article

Recent advances in composite resins- An Overview

[1]Diya Sharma, [2]Yesh Sharma, [3]Akshat Waran, [4]Kailash Asawa, [5]Mridula Tak, [6]Sai Kancharlawar, [7]Ankita Rawal

[1]Intern, Department of Public Health Dentistry, Pacific Dental College and Hospital, Udaipur, Rajasthan, India
[2,3]Senior lecturer, Department of Conservative Dentistry and Endodontics, Pacific Dental College and Hospital, Udaipur, Rajasthan, India
[4]Professor and Head, [5]Professor, [6,7]Postgraduate Student, Department of Public Health Dentistry, Pacific Dental College and Hospital, Udaipur, Rajasthan, India

ABSTRACT:
Composite dental restorations represent a unique class of biomaterials with severe restrictions on biocompatibility, curing behavior, esthetics, and ultimate material properties. These materials are presently limited by shrinkage and polymerization-induced shrinkage stress, limited toughness, the presence of unreacted monomer that remains following the polymerization, and several other factors. Fortunately, these materials have been the focus of a great deal of research in recent years with the goal of improving restoration performance by changing the initiation system, monomers, and fillers and their coupling agents, and by developing novel polymerization strategies.

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Corresponding author: Diya Sharma, Intern, Department of Public Health Dentistry, Pacific Dental College and Hospital, Udaipur, Rajasthan, India

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INTRODUCTION

The accordance of material used till date were not aesthetically acceptable with the tooth. Since the mental health of the patient relies on aesthetic quality of the restoration, in the same way patient's physical / dental health depends upon biological and technical qualities of the restoration.[1]

Since last 50 years, these composite resins have been used in clinical dentistry.[3] as it restores biological tissue not only in appearance but also in function. Composite resins have taken over amalgam as a posterior restorative material.[2] Resin reinforced with silica / porcelain particle constitute these composite resin.[4] Micro leakage and post-operative sensitivity further leading to low protection due to discoloration, tensile pressure and scrapped area van be considered to be imposing flaws of these materials[5]

These composite resin contribute to multifarious success of modern biomaterial research[2]. Certain properties of inorganic filler of composite resin that comprises of rigidity, strength and hardness and that of organic resin matrix include subsequent polymerization for rapid setting, sufficient fluidity for easy application. A silane coupling agent bonds the filler and matrix together[6]. In order to directly bond the composite resin filler to dentine / enamel a separate binding agent is used.[7]

ADDITIONALLY, TO STRENGTHEN THE COMPOSITE RESIN VARIOUS OTHER VARIANTS HAVE BEEN FOUND WHICH INCLUDES

- Nanocomposite
- Fiber reinforced composite
- Direct composite resin
- Indirect composite resin
- Silver diamine fluoride (SDF) composite
- Antimicrobial composite
- Micro-hybrid composite
- Bulk- fill composite
- Gingival-color composite
- Self healing composite
- Stimuli responsive composite
- Ormocers
- Compomers

DEFINITION
Skinners (1991) defined composite as "a compound of two or more distinctly different materials with properties that are superior or intermediate to those of the individual constituents."[8]

CLASSIFICATION:[9]
BASED ON DENSITY
BOG L ET AL (2007)
1. Low density (Fluid)
2. Medium density (Conventional)
3. High density (Packable)
4. Super high density (Ceromers)

TYPES OF COMPOSITE RESIN[10]
The most popular classification is based on filler particle size given by Lutz and Phillips in 1983.
According to this classification, composite resins were divided into
1. Macro filled composites,
2. Micro filled composites and
3. Hybrid composite

RECENT ADVANCES IN COMPOSITE
Recent advancements expedite the utilization of composite resin in various industries such as aerospace, automotive, and construction.

1. ORGANICALLY MODIFIED CERAMIC OLIGOMERS (ORMOCER)
An initialism of organically modified ceramic technology (Cunha et al ., 2003)- ORMOCER is considered to be molecule-sized hybrid structure.[11,12] They are high molecular weight, relatively low viscosity crosslinking molecules and flexible. The inorganic network provides abrasion resistance through its glass-like structure and low water sorption due to its hydrophobicity and low-level polymerization shrinkageis due to large spacing between crosslinks. [11,12,13]

INDICATIONS:[14]
1. As a liner of class I and II cavities
2. Restoration of GV BLACKS class I, II, V cavities
3. Reconstruction of traumatically damaged anteriors
4. Splinting of loose teeth
5. As a extended fissure sealant
6. 6.Fabrication of composite inlay
7. Core build up

CONTRAINDICATIONS:[14]
In areas where esthetics is of prime importance

ADVANTAGES:[11,12,14]
1. Better marginal seal
2. Limited cure shrinkage
3. 3.Very high biocompatibility
4. Good manipulation properties
5. Excellent esthetics

DISADVANTAGE:[14]
1. Highest cytotoxicity
2. Tendency to discolor.
3. Lower wear resistance.

1. NANOCOMPOSITES
The composite is said to be made up of a matrix and filler reinforcement. The filler reinforcement brings to the composite material its greater mechanical performance, and the role of the matrix is to transmit the external mechanical load along with protection of the composite restoration against external attack[15]. These composites are considered to have approximately 60% volume filler loading, making the nano-filled resins as strong as the hybrid and micro-hybrid resins. Nanofillers may consist of colloidal silica or ormocers, such as Inceram X from Dentsply. Nanoparticle filled dental particles can provide an enhanced fracture toughness and adhesion to tooth tissue.[12,16,17,18]

ADVANTAGES[15]
1. Improved mechanical characteristics
2. High cost
3. Resistance to corrosion
4. Improved handling properties
5. Good thermal stability
6. Increased transulency leading to surface gloss

2. CONDENSABLE COMPOSITES OR PACKABLE COMPOSITES OR POLYMER RIGID INORGANIC MATRIX MATERIAL (PRIMM)
The filler mainly constitutes Aluminium oxide, Silicon oxide glass particles or barium aluminium silicate or strontium glasses. The colloidal silica ultrafine particles are also encompassed to control the handling characteristics such as resistance to flow, condensability,viscosityand reduced stickiness[19]. The physical and mechanical behaviour of these materials beat hybrid-composites and silver amalgam [20]. The clinical performance of these materials are similar to that of the hybrid composites [21,22,23].

INDICATION
In class II cavities.

3. FIBER REINFORCED COMPOSITES (FRC)
The most commonly used fibers in dental composites are Glass fibers, carbon fibers polyethylene fibers, aramidfibers, etc.Orientation of these fibers can be done in different directions; unidirectional, weave type, mesh type, etc., in the resin matrix in order to improve the physical and mechanical properties of composites. The durability of the fiber-reinforced compositeuis an subject to essential factors including fiber loading within the resin, the orientation of fibers,adhesion of fibers to the matrix ,volume of fibers in composite matrix, etc[24]. To provide bonding

between resin matrix and fibers silane coupling agents are commonly used[25].

ADVANTAGES[24,26]
1. Strength
2. Stiffness
3. Improved wear resistance

INDICATIONS: [24,26]
1. Fixed partial denture
2. Periodontal splinting/ post trauma splint
3. Fixed orthodontic retainers
4. Reinforcing or repairing dentures
5. Root posts
6. Reinforced biomedical implants.

1. Self healing / repairing materials[27]

Ithas a inbuilt intrinsic mechanism to manage themicrocracking before it starts affecting the integrity of the material.

INDICATIONS

GV BLACKS Class I, II cavities.

CONTRAINDICATIONS

GV BLACKS Class III, IV V cavities.

ADVANTAGES:
1. Increased resistance to fracture.
2. Reduces polymerization shrinkage
3. Better durability and toughness as compared to conventional composites
4. Increased flexural strength and wear resistance.

DISADVANTAGES

Technique sensitive.

1. ANTIMICROBIAL COMPOSITE[28]

The antimicrobial properties of these composites can be accomplished by introducing agents such as silver(Peng et al., 2012), titanium particles, immobilized antibacterial components(Xie et al., 2011; Imazato et al., 2012)or one or more antibiotics into the material. New dental composites that contain quaternary ammonium dimethacrylate (QADM)and silver nanoparticles (AgNP)have been manufactured and observed to inhibit Streptococcus mutans (S.mutans)(Zhang et al., 2013; Cheng et al., 2018).

ADVANTAGES
1. Reduces formation of secondary caries near margin of restorations due to inhibition of bacterial growth
2. Enhanced biocompatibility
3. Reduced demineralization and buffering of acids produced by cariogenic microbes.

DISADVANTAGE
1. Deterioration of physical and mechanical properties of the material
2. Short lived antibacterial activity
3. Toxic effects of released materials.

1. FLOWABLE COMPOSITE

They lack adequate strength to withstand high stresses as the filler content was reduced[29]. These composite show more polymerization shrinkage and less elastic moduli due toincrease in resin content[29-32]. These composite tend to wet the tooth surface better and flows easily into the every undercuts. It forms in thin layers reducing the formation of air pockets at the tooth-restoration interface[29, 33].

Compared to camphorquinone amine system, these materials contain a germanium based photoinitiator which is more effective and has a much higher significant yield[34].

2. COMPOMERS

They are resultant of a combination of compositesand glass ionomer cements and were showcased as polyacid-modified composite resins. These material gives fluoride articulation, can adhere efficiently to dental hard tissues and is a biocompatible material[35]. The core of compomersis shaped ofpolycarboxylate polymersand methacrylate with resins which can undergo polymerisation, glass filling particles, for eg, fluoroaluminoxylate, and also stronsiumfluoroxylate or it may also contain barium fluoroxylateglass and photograph triggers (camphoroquinone/amineframework) and balancers.[36]

3. SILORANES (SILOXANE + OXIRANE)

The purpose of oxyrane configuration is tolessen polymerisation shrinkage that usually occurs andthe siloxane works in development of a hydrophobicstructure. These resins also help indiminishing negligible discoloration to a base,expanding protection from debilitating andgiving protection from fluids, not beingmutagenic.Investigationsdiscovered that the shrinkage pace of silorane-based compositesis<1%.[37, 38]

4. INDIRECT COMPOSITE RESIN

These resins exhibit contour,superior marginal adaptation, and proximal contact as it is fabricated on a die than in cavity preparation[16,39]. Microhybridfiller of second generation composites havediameter of 0.04-1 µ with twice the filler content than that of first generation. The polymerization shrinkage is diminishedby lessening the organicresin matrix, and the mechanical properties andwear resistance is improved by expanding filler load[15].

5. OMICHROMA

These material with its 260nm round filler particles use auxiliary shading. To cause production of red-to-yellow shading, fillers of essentially specific size and shape are anticipated.Theround fillers that consolidates with the reflected shade of the patient's

encompassing dentition, making the ideal match from A1 to D4 andbeyond lead to red to yellow shading[40].

6. GIOMER[41]

Giomer is a resin-based dental adhesive, fluoride-releasing material that comprises Pre-Reacted Glass-ionomer fillers. Glassionomers have high fluoride release, low polymerisation shrinkage, are easy to place, fast-setting ,hydrophilicity and bonding ability to enamel and dentin. Benefits of reduction in microleakage and immediate finishing and polishingare due to light activated glass ionomer.

A surface prereacted glass (S-PRG)filler to the resin matrix is present in Giomer and this filler helps in fluoride release.BISGMA(Bisphenol-A glycidyl dimethacrylate),UDMA(urethane dimethacrylate), BISMPEPP(2, 2 bis(4-2 methacrlyloxy)ethoxy)phenyl propane), TEGDMA(triethylene glycol dimethacrylate are also present in organic matrix.

INDICATIONS

1. GV BLACKS III, IV V cavities.
2. Restorations of deciduous teeth.
3. As a base/liner under restorations.
4. Repair of fractured incisal edges
5. Restoration of fractured composites and porcelain
6. As a fissure sealant
7. Veneers and post
8. Cervical erosion and root caries.

CONTRAINDICATIONS

In areas where esthetics is of prime concern.

ADVANTAGES

1. Better esthetics
2. Improved handling and physical properties compared to conventional composites
3. Increased radioopacity compared to conventional composites
4. Low shrinkage stress
5. Shade stability before and after curing.
6. High fluoride release and recharge capability.

DISADVANTAGE

1. Rough surface resulting in tooth discoloration
2. Vickers hardness value are less than composite
3. Not beneficial in high recurrent caries lesions as release of fluoride is less than that of GIC
4. Long term fluoride release is questionable.

STIMULI RESPONSIVE / SMART MATERIALS

External stimulus such as temperature, pH, mechanical stress, moisture, etc are the properties on which these material depend. Depending on the pH, these composite materials release fluoride, calcium, and hydroxyl ions into the surroundings of the filling. A significant number of ions than that at the neutral pH are released especially when the pH is less than 5.5. They also provideadditional caries protection[42-44].

SELF-ADHERING COMPOSITES

Also called as compobondsthat combines the advantages of both dental adhesives and restorative materials technologies (8th generation) in a single product[45]. Self-etching dentin bonding agents and nano-filled resins are its benefits. These composite got rid of the precursory bonding stage necessary to adhere, resin to tooth substrate, thus reducing the chances of postoperative sensitivity. They act as shockabsorbers beneath the resin-based composite restoration as they also have the properties of 7th generation of dentin bonding agents[46].

CALCIUM PHOSPHATE NANOPARTICLES[47,48]

To make mineral releasing dental composites, calcium phosphate such as Hydroxyapatite phosphate, anhydrous calcium phosphate, tetra calcium phosphate and dicalcium phosphate anhydrous have been used as fillers.Stress-bearing capacity and ion release that inhibit dental caries is improved due to incorporation of these particles.

BELLGLASS HP[49,50]

Indirect restorative material introduced in 1996 by Belle de St. Claire.are cured under pressure (29 PSI) at an elevated temperature of 1380C and in the presence of nitrogen gasdue to which they have increased polymerization rate. Due to curing in the presence of nitrogen gas they have increased wear resistance.As nitrogen gas provides an oxygen-free environmentthe rate of curing is also improved. There is reduction in translucency of composite and delay in polymerization reaction due to role of oxygen as polymerization inhibitor.

ART GLASS[49,50]

Art glass isa nonconventional dental polymer. The fillers used are radiopaque Barium glass with an average particle size of 0.7 micrometres and colloidal silica. They are used in making indirect restorations such as inlays, onlays, and crowns. Improved wear resistance and other physical and mechanical properties due to the greater level of crosslinking are displayed by these material. For curing of these resins,a special light curing unit such as Xenon stroboscopic light-curing device with the emission ranges from 300-500 nm is used.

ADVANTAGES

1. High wear resistance compared to traditionalcomposites
2. Good marginal adaptation
3. Esthetics
4. Superior proximal contact.

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