



REVIEW ARTICLE

Recent Advancements in Restorative Dentistry : An Overview

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Abstract:

The important goal in dentistry is to provide best dental care to the patients. Day by day, science is undergoing great revolutions that are leading the humanity towards a new era of dentistry. Nanotechnology is introduced in conventional GIC and resin-modified GIC to improve the mechanical properties of GIC. 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 need to improve shrinkage properties and wear resistance is obvious for dental composites and a vast number of attempts have been made to accomplish these aims. Based on recent clinical information, it appears that major successes have been achieved in reaching the goal.

Keywords: GIC, Composite, Resin, Nanocomposite



1 | INTRODUCTION:

The most fundamental aspects of dental treatment is the restorative dentistry. [1] Many refinements and improvements in quality of various materials and processes used in the restorative dentistry came into existence with the beginning of 20th century. [2] For their use in dentistry, dental materials have been especially designed and are made of fabricated materials. The characteristics of different available dental restorative materials vary

according to their intended purpose. [3] With the advancement, number of new restorative materials

Supplementary information The online version of this article (<https://doi.org/10.15520/jcmro.v3i07.311>) contains supplementary material, which is available to authorized users.

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have been discovered which have shown significant improvement in the quality of restoration. The aim of this review article is to describe the various advanced restorative materials which have been used now a days for restoration with improved properties.

2 | DISCUSSION:

Development in materials, equipment and techniques have transformed both the art and science of restorative dentistry, and future advancements will certainly continue the evolution of this discipline. For 150 years, dental amalgam has been used a restorative material. With the increase in awareness and adverse effects of mercury on environment, alternative filling materials have become increasingly more favored. [4]

(a) Glass ionomers

1. Resin modified glass ionomer [5–8]

They were introduced in 1988 by **Antonucci et al** to overcome the problems associated with the conventional Glass - ionomers and at the same time preserving the clinical advantage of conventional materials. They are a hybrid of glass ionomer and resin composites. A dimethyl methacrylate monomer, HEMA is grafted in polyacrylic acid. With the exposure of light, polymerization is initiated along the methacrylate groups, after that the acid - base reaction is carried out. It has been seen in several reports that the rate of fluoride release by RMGIs is similar to that of conventional GI. However, this release is influenced by the formation of complex fluoride derivatives with their reaction with polyacrylic acid, accompanied by the type and amount of the resin used in the light polymerization. Release of fluoride from various RMGIs during the first 24 hr is maximum with 5-35 $\mu\text{g}/\text{cm}^2$ depending on the storage environment.

Advantages:

Improved working time, Early resistance to water attack, Chemical and micromechanical bonding to tooth, Nearly insoluble, Better esthetics and strength, Good radio opacity, Bond easily to composite, Improved mechanical and physical properties and Minimal or no post-op sensitivity.

Uses of RMGIC :

Luting stainless steel crowns, space maintainers and bands in pediatric cases, Liner and base, Pit and fissure sealant, Core build up, Repair material for damaged amalgam cores or cusps and Retrograde filling material.

2. Compomers : (Polyacid modified Resin composite) [6, 9–11]

According to Mclean and Nicholson compomers can be defined as : “Materials that may contain either or both of essential components of a GIC but at levels insufficient to carry out the acid curing reaction in the dark”. Hence photo activation is absolutely necessary for this type of material.

It is formed by combination of composites (COMP) and Glass ionomers (Omer). They contain dimethacrylate monomer and two carboxylic groups along with ion-leachable glass and absence of water in the composition. The glass particles are fillers and are partially silanated to ensure bonding with the matrix. When compared with RMGIC, they have limited, dual set mechanism. The dominant setting reaction is the resin photo polymerization and no acid-base can occur until later when the material absorbs water. Like GIC, they also release some fluoride ions.

Properties :

Fluoride release : Fluoride is released for more than 1 yr and at the same rate but the it is less than RMGIC. It does not act as a fluoride reservoir like RMGIC.

Strength : Compressive and Tensile strength equal to that of hybrid resin composite but exceed that of RMGI's

Indications:

- Restoration of erosion, Class III using lingual approach
- Sealing root surfaces for over dentures
- Potential root canal sealers
- Retrograde filling materials in Endo emergencies
- Core build up
- Underneath composite restorations.

Contraindications:

- Lesions involving large areas of labial surface where esthetics is of prime concern.
- Class II, IV lesions
- Lost cusp areas
- Underneath metal /PFM crowns where light cannot penetrate.

Advantages:

Easy to use, Superior working characteristics, Easy adaptability, Good esthetics and Good fluoride release.

Dyract was one of the successful 1st compomer. Many new compomer restorative materials are available which claim to be better than 1st and 2nd generation compomers. Such as dyract Ap, compo glass F, compo glass Flow, F2000, Hytac, Aplutip.

3. Condensable / Self hardening GIC [6, 9, 11]

Developed in 1990's as filling material for ART. These are purely chemically activated resin-modified glass ionomer cements (RMGICs) with no light activation at all. It is used mainly in pediatric dentistry for cementation of stainless steel crowns, space maintainers, bands and brackets. It has high viscosity. High viscosity is due to addition of polyacrylic acid to the powder and fine grain size distribution.

Composition:

Powder : Alumino silicate glass 90 – 95%.

Poly acrylic acid 3 – 5%.

Liquid : Poly acrylic acid – 45%

Distilled water – 50%

Indications:

Class I and Class II in primary teeth, Geriatric restorative in class I, II, III, V, Long term temporaries in rampant caries, Class I and Class II in permanent teeth in non-stress bearing areas, Core build up and deep pit and fissure restoration.

Advantages:

Packable/condensable, Easy placement, Non - sticky, Reduced early moisture sensitivity, Rapid

finishing, Improved wear resistance and low solubility in oral fluids.

4. The Low Viscosity/Flowable GIC [9, 12]

Fluoride recharge material : To overcome the shortcomings faced by fluoride releasing material, a new material has been developed for fluoride release. Greater the fluoride release in a material, more open is the structure resulting in low strength. In order to improve the strength of these fluoride containing materials, if they are made more dense and strong, then the efficacy of F release is decreased. Soon after placement, there is sudden burst of fluoride release followed by a rapid decline in ion release rate.

This modified GIC has 2 part : Restorative part and Charge part

The restorative part is used the usual way when the 1st burst of fluoride is expelled, the therapeutic potential of the restoration spent. The material is given a second fluoride charge by using a gel material - charge part that replenishes the fluoride site in the restoration by ion exchange and recovers the fluoride release and therapeutic potential of the restoration. This is achieved without replacing the material.

Uses:

As pit and fissure sealant, lining, endodontic sealers, sealing of hypersensitive cervical areas .eg: Fuji lining LC, Fuji III and IV, Ketac –Endo.

5. Giomers [6, 9, 13]

This is a combination of glass ionomers and composite and is a new type of restorative material

Properties: Fluoride release and recharge, Excellent esthetics and polishability and Biocompatibility.

Giomers are resin based and contain pre-reacted glass ionomer (PRG) particles. The particles are made up of fluorosilicate glass which reacts with poly acrylic acid before incorporation into the resin. The pre reaction can involve only the glass particles surface (known as surface pre reacted glass ionomer or S – PRG) or the entire particle (termed fully pre reacted glass ionomer or F-PRG).

Giomers are similar to compomers and resin composites in being highly activated and requiring the use of a bonding agent to adhere to tooth structure. Giomers release fluoride but do not have the initial

“burst” type of fluoride release and long term release (ie. 28 days) was lower than GIC, RMGIC and compomer. On polishing with sofex discs - they have a smoother surface than GIC. Commercially available giomers – Beautiful shofu.

(b) Amalgam:

Adhesive amalgam restorations [14, 15]

Delayed interfacial marginal leakage occurs at the amalgam preparation interface which is sealed by corrosion products from amalgam after few months. However, this process may take more than 6 months for copper rich amalgam alloys. High copper amalgam undergo a much slower corrosion process than conventional amalgam alloys. To overcome this marginal leakage, dentin adhesive systems have been used under Hg based amalgam restorations and Gallium based amalgam restorations. For eg. All – Bond 2, Amalgambond Plus with HPA powder, Panavia, Optibond 2.

The attachment mechanism between amalgam and the adhesive may be micromechanical enlargement of the uncured adhesive material with the setting amalgam mix during condensation of the amalgam. Initial Bond strength values were around 3–5 mpa, some current adhesive systems provide bond strengths in the range of 10 – 14 mpa. As a safety precaution primary mechanical retention features are still recommended when an adhesive system is used with amalgam. The residual tooth structure becomes more resistant to fracture with the use of adhesive amalgam restorations.

(c) Composites:

1. Packable composite [16, 17]

Also known as condensable composites. It is composed of resin matrix and an inorganic ceramic component. Rather than including the filler particles into the composite resin matrix, resin is incorporated into the fibrous ceramic filler network The filler consists of Aluminium oxide, Silicon oxide glass particles or barium aluminium silicate or strontium glasses.

These were developed in a direct effort to produce a composite with handling characteristics similar to amalgam. Hence the name “packable” or “condensable”. It is intended primarily for Class I and Class II restorations.

Distinguishing characteristics of packable composites

Less stickiness and Higher viscosity

When compared to traditional hybrid composites that allow them to be “packed” in a manner that somewhat resembles amalgam placement, packable composites are designed to be inherently more viscous to afford a “feel” upon insertion, similar to that of amalgam. As there is increased viscosity and resistance to packing, some lateral displacement of the matrix band is possible.

Their development is an attempt to accomplish two goals : Easier restoration of a proximal contact and Similarity to the handling properties of amalgam. They do not completely accomplish either.

2. Flowable composite [18–20]

Flowable composites have low viscosity which possess particle size and particle size distribution similar to that of hybrid composites but with reduced filler content which decrease the viscosity of the mixture as the amount of resin increased. Since, this composite were developed with specific handling characteristics in mind, their range of clinical uses is quite varied.

Mechanical properties are inferior to those of standard hybrid composites, Inferior physical properties, Low wear resistance, Low strength, Low resistance to fracture and Lower filler content.

Popular features

Easy to use, Favourable wettability, Handling properties.

Indications

Some small class I restorations, As pit and fissure sealants, Marginal repair materials and as a first increment placed as a liner under hybrid or packable composites.

Flowable composites are essentially “thinned down” composites with fewer filler particles into the resin.

Baoudi K et al (2015) suggested in a systematic review that the flowable composites are the promising aesthetic restorative materials for the future and will become markedly useful material in various aesthetic restorative procedures.

3. Ceromers [21, 22]

It is an indirect composite materials and is commercially available as Targis. It is a combination of Ceramic optimized polymers (ceromers) and a fiber reinforced composite framework material. Ceromers combine the advantages of ceramics with those of state of the art composites. Ceromers are composed of specially developed and conditioned fine particle ceramic fillers of submicron size (0.04 and 1.0 mm) which are closely packed (approx. 85 wt percent) and embedded in an advanced temperable organic polymer matrix.

Ceromers combine the advantages of ceramics and composites.

Durable esthetics quality, Abrasion resistance, High stability, Ease of final adjustment, Excellent polishability, Effective bond with luting composite, Low degree of brittleness, Susceptibility to fracture and Possibility of repairing restorations in the mouth.

In addition to being esthetic, ceromer restorations also conserve tooth structure. Furthermore, adhesive cementation with advanced luting composites assures the stability of these restorations.

4. Ormocers [23–25]

Ormocres are Organically Modified ceramics. It was developed by Fraunhofer institute for Silicate Research. Ormocers was introduced as a dental restorative for the first time in 1998. These materials are also used in electronics, micro system technology, refinement of plastics, conservation and corrosion coatings, functional coatings of glass and anti-scratch protective coatings. Ormocers have inorganic as well as an organic network.

Ormocers consist of three components - organic, inorganic portions and the polysiloxanes. The proportions of these components can affect the mechanical, thermal and optical qualities of the material. The inorganic components bound to the organic polymers by multifunctional coupling agent silane molecules. After polymerisation, the organic portion of the methacrylate groups form a three-dimensional network.

Advantages: Better marginal seal, Large size of monomer molecule minimizes polymerization shrinkage.

Disadvantage: Highest cytotoxicity, Tendency to discolor and Lower wear resistance.

5. Fibre reinforced composite [26–28]

It consists of fibre material held together by resinous matrix. They are structural materials that have at least 2 distinct constituents - the reinforcing component which provides strength and stiffness and the surrounding matrix supports the reinforcements and provides workability. In dental applications, polymeric or resin matrices reinforced with glass, polyethylene or carbon fibres are most common.

Evaluation of FRC's:

The first attempts to use fibre reinforced cement in clinical dentistry began in the 1960's and 1970's when reinforcement of standard polymethyl methacrylate dentures with glass or carbon fibres was initiated. Most of the proposed procedures involved intuitive manual placement of fibres into dental resins. This approach was cumbersome and the degree of improvement was far below that with commercial applications.

The lower than expected mechanical results were due to

- Lower amount of fibre incorporated into the resin –15% by volume compared to 50 – 70% with industrial products.
- Poor wetting of the fibre bundles by the resin resulting in insufficient coupling or even gaps between fibres.

In the late 1980's 2 approaches for effective coupling and complete impregnation of the fibre bundles were evolved.

- Manual application of a low viscosity resin to the fibre bundles. Though this provides complete wetting, it is also cumbersome and requires another step in the procedure. It offers versatility in the selection of fibres and resin.
- Use of pre impregnated fibre bundles by controlled manufacturing process which involves pulling of the fibre bundles through a convoluted path that forces the resin into the fibre bundles.

This complex process allows for

- a) High fibre content
- b) Complete wetting
- c) Minimum void content
- d) Control of cross sectional diameter in pre impregnated FRCs

Glass reinforced thermoplastics were used in early experimental pre impregnated FRCs. But the thermoplastic resin matrix was difficult to manipulate and offered poor bonding to tooth structures. These problems were resolved by switching to bis-GMA based resin as the matrix for FRCs.

Application of FRCs in dentistry:

Crown framework, Anterior or posterior fixed prosthesis, Chairside tooth replacements, Appliances like periodontal splints and Endodontic posts fabrication.

Characteristics of FRCs

- Good overall mechanical properties
- Superior strength / wt ratios compared to most alloys
- Non corrosive properties
- Potential translucency
- Radiolucency
- Good bonding properties
- Good flexural strength
- Case of repair.

6. Nanocomposite [29–31]

Nanotechnology in advanced dental materials

Nanotechnology, also known as molecular engineering or nanotechnology. It involves the production of functional materials and structures within the range of 0.1 to 100 nm by various physical or chemical methods. The use of nanomaterials stems from the idea that they may be used to manipulate the structure of materials which provide dramatic improvements in chemical, electrical, mechanical and optical properties. Nanofillers and Nanocomposites have been

developed using advanced methacrylate resins and curing technologies.

There are 2 new types of nanofiller particles

Nanomeric or NM – particles and Nanoclusters

Nanomeric involves monodisperse non aggregated and non agglomerated silica nanoparticles.

For synthesis of dry powders of nanosized silica particles 20 and 75 nm in diameter, aqueous colloidal silica sols were used. The dental nanocomposite system show high translucency, high polish and polish retention which is similar to that of microfills while maintaining physical properties and resistance equivalent to those of several hybrid composites. The strength and esthetic properties allow to use the resin based nanocomposite for both anterior and posterior restorations.

Advantages:

Improved mechanical characteristics, Good thermal stability, High cost, Corrosion resistance, Increased translucency and Improved handling properties

7. Antimicrobial composite [19, 31, 32]

Introduction of agents such as silver or one or more antibiotics into the material, antimicrobial properties of composites may be accomplished. Silver and titanium particles were added to introduce the antimicrobial properties which enhance the biocompatibility of the composites. The antibacterial properties were based on contact mechanism instead of leaching which lasted for at least 1 month.

8. Stimuli responsive composite [19, 33]

Stimuli-responsive materials possess properties that may be considerably changed in a controlled fashion by external stimuli. These stimuli can be : temperature change, mechanical stress, pH, moisture, or electric or magnetic fields. These composites are used for treating the secondary caries in the posterior teeth region and have proven to be very effective.

9. Self healing composite [31, 34, 35]

Due to different physical, chemical and biological stimuli, materials usually have limited lifetime and get degrade which include external static (creep) or dynamic (fatigue) forces, internal stress states, corrosion, dissolution, erosion, or biodegradation. This ultimately leads to deterioration of the material

structure and finally failure of the material. Epoxy resin composite was one of the first self-repairing or self-healing synthetic materials which shows some similarities to resin-based dental material. If a crack occurs in the epoxy composite material, some of the microcapsules are destroyed near the crack and release the resin. The cracks were filled by resin and reacts with a Grubbs catalyst dispersed in the epoxy composite, which results in polymerization of the resin and repair of the crack.

3 | SUMMARY:

Various advances have been made in restorative materials to improve the basic properties of the materials, keeping in mind the biocompatibility and its bonding with tooth structure. Together with the use of nanotechnology, knowledge of materials and developments in biomaterials, it is thought that high quality dental restorative materials will be produced in the future.

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How to cite this article: Kalotra J., Gaurav K., Kaur J., Sethi D., Arora G., Khurana D. Recent Advancements in Restorative Dentistry : An Overview. Journal of Current Medical Research and Opinion. 2020;522–530. <https://doi.org/10.15520/jcmro.v3i07.311>