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Recent material advances for paediatric restorative dentistry

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Abstract: Dental caries is the most prevalent infectious disease affecting children globally. Children of all races, castes, and creeds are impacted. Children are more susceptible to dental caries due to refined diets and poor oral hygiene. Thorough clinical assessment and diagnosis of dental caries are essential components of an all-encompassing treatment strategy. The dentition's developmental stage, the patient's oral hygiene, the caries-risk assessment, the likelihood of timely recall from the parents, and the child's cooperation during treatment are all important considerations. Dental technology is entering a new era as a result of significant advances in restorative science.

***Keywords*:** dental caries, composite, pediatric dentistry, restorative dentistry, glass ionomer cement, nanotechnology.

Introduction

The primary goal of paediatric dentistry is to give patients the best dental care possible, which can be accomplished with the assistance of a qualified Pedodontist and their team. The incidence of dental caries is higher in the paediatric population due to factors such as poor oral hygiene, refined diets, lack of motor dexterity, and specific tooth morphology.[1] Materials used in dental restorative procedures are made with their intended use in mind. Research is always being done to develop new materials for restorative dentistry so that patients can receive better care. As people become more aware of the harmful effects of mercury on the environment, people are favouring alternative filling materials instead of dental amalgam.[2]

RESTORATIVE MATERIALS IN PEDIATRIC DENTISTRY

Glass ionomers

Glass ionomer cement (GIC) is restorative materials which are made up of calcium, strontium aluminosilicate glass powder (base) combined with a water-soluble polymer (acid). When the components are mixed together, they undergo a setting reaction involving neutralization of the acid groups by the powdered solid glass base.[3]

Properties

Adhesion

By bonding a restorative material to tooth structure, the cavity is theoretically sealed, protecting the pulp, eliminating secondary caries, and preventing leakage at the margins.

Margin adaptation and leakage

The coefficient of thermal expansion of conventional GIC is close to that of dental hard tissues and has been cited as a significant reason for the good marginal adaptation of glass ionomer restorations.[4]

Fluoride release

Fluoride is released from the glass powder at the time of mixing and lies free within the matrix. It can, therefore, be released without affecting the physical properties of the cement.

Esthetics

Conventional GIC is tooth colored and available in different shades.

Biocompatibility

The biocompatibility cement is very important because they need to be in direct contact with enamel and dentin if any chemical adhesion is to occur.

Color and translucency

Both conventional and resin-modified GIC are available in various shades and provide acceptable color matching and translucency

Radiopacity

Conventional GIC is radiolucent, but resin-modified and lining GIC are radiopaque due to the presence of lanthanum, barium, or strontium in the powder.

Strength and fracture resistance

The compressive strength is similar to that of zinc phosphate cement, and its diametral strength is slightly higher. The modulus of elasticity of GIC ranges from 7 Gpa to 13 Gpa.[5]

Abrasion resistance

GIC has less resistance to abrasion than composite resins, but abrasion resistance improves as the cement matures.

Solubility and disintegration

Properly set GIC exhibits low solubility in the oral environment. In patients with xerostomia, the use of conventional GIC should be avoided as the cement will undergo rapid disintegration.

RECENT ADVANCEMENTS IN GLASS IONOMER CEMENT

Anhydrous

In this modification, the liquid is delivered in a freeze-dried form that is then incorporated into the powder. The liquid to be used is clean water only, and this may enhance shelf-life and facilitate mixing.[5]

Resin-modified glass ionomer

They were first presented by Antonucci et al. in 1988 in an effort to preserve the clinical benefit of conventional materials while also addressing issues with traditional glass ionomers. They are a cross between resin composites and glass ionomer. Grafted into polyacrylic acid is HEMA, a dimethyl methacrylate monomer. The methacrylate groups and polymerization are both triggered by light exposure; the acid-base reaction then proceeds. It has been seen in several reports that the rate of fluoride release by resin-modified glass ionomers (RMGIs) is similar to that of conventional GI. The kind and quantity of resin utilised in the light polymerization, as well as the creation of complex fluoride derivatives and their reaction with polyacrylic acid, all have an impact on this release. Fluoride release from different RMGIs varies within the first 24 hours, with a maximum of 5–35 μg/cm2, contingent on the storage conditions.[6]

Nano-ionomer

The nano-ionomer delivers greater wear resistance, esthetics, and polish compared to other glass ionomers, while offering fluoride releases similar to conventional and RMGIs.

Compomer

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, photoactivation is absolutely necessary for this type of material. It is formed by the combination of composites and glass ionomers (Compomer). They are composed entirely of ion-leachable glass, two carboxylic groups, dimethacrylate monomer, and no water. To guarantee bonding with the matrix, the glass particles serve as fillers and are partially silanated. They have less of a dual set mechanism than RMGI cement (RMGIC). Resin photopolymerization is the primary setting reaction; acid-base reactions cannot happen until the material absorbs water. They also release some fluoride ions, just like GIC.[7]

Ceramic-reinforced glass ionomer

Ceramic-reinforced posterior GIC features are stronger.

Condensable/self-hardening glass ionomer cement

It was developed in 1990s as filling material for ART. These are purely chemically activated RMGICs with no light activation at all. It is used mainly in pediatric dentistry for the cementation of stainless-steel crowns, space maintainers, bands, and brackets. It has high viscosity. High viscosity is due to the addition of polyacrylic acid to the powder and fine grain size distribution: composition: powder: aluminosilicate glass – 90%–95%, polyacrylic acid – 3%–5%, liquid: polyacrylic acid – 45%, and distilled water – 50%. It is indicated in 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 nonstress bearing areas, core build-up, and deep pit and fissure restoration. It has the advantages of being packable/condensable, easy placement, nonsticky, reduced early moisture sensitivity, rapid finishing, improved wear resistance, and low solubility in oral fluids.[8]

The low viscosity/flowable glass ionomer cement

It is a fluoride recharge material. A new material for fluoride release has been developed in order to address the shortcomings of the fluoride releasing material. A material's structure becomes more open with increased fluoride release, which reduces strength. If these fluoride-containing materials are strengthened by increasing their density and strength, the effectiveness of F release will be diminished. Fluoride release occurs in a sudden burst shortly after placement, and the rate of ion release rapidly decreases thereafter. This modified GIC has two parts: the 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 is spent. The material is given a second fluoride charge 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. It is used as pit and fissure sealant, lining, endodontic sealers, and sealing of hypersensitive cervical areas. Examples of commercially available materials are Fuji Lining LC, Fuji III and IV, and Ketac-Endo.

Giomers

This novel class of restorative material combines glass ionomers and composites to provide outstanding aesthetics, polishability, biocompatibility, and fluoride release and recharge. Giomers consist of prereacted glass-ionomer (PRG) particles and are resin-based. Prior to being incorporated into the resin, the fluorosilicate glass that makes up the particles undergoes a reaction with polyacrylic acid. The pre-reaction can involve only the glass particles surface (known as surface PRG ionomer or S-PRG) or the entire particle (termed fully PRG 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 the tooth structure. Giomers release fluoride but do not have the initial “burst” type of fluoride release, and long-term release (i. e., 28 days) was lower than GIC, RMGIC, and compomer. On polishing with soflex discs, they have a smoother surface than GIC, commercially available giomers – Beautiful shofu.[9]

Dental Composites

A polymeric dental restorative material reinforced with silica particles was developed by Bowen of the National Bureau of Standards to improve the physical properties of unfilled acrylic resins. The restorations commonly referred to as composites were first made possible by the introduction of this filled resin material in 1962. Nowadays, composites are the most widely used tooth-colored materials; acrylic resin and silicate cement have been totally superseded.[10]

Recent advances

Packable composite

Another name for it is condensable composites. It is made up of an inorganic ceramic component and a resin matrix. The filler, which is made up of aluminium oxide, silicon oxide glass particles, barium aluminium silicate, or strontium glasses, is integrated into the fibrous ceramic filler network rather than the composite resin matrix. The terms "packable" and "condensable" refer to the fact that these were created specifically to create a composite that would handle like amalgam. It is intended primarily for Class I and Class II restorations. Distinguishing characteristics of packable composites are that they are less sticky and possess higher viscosity when compared to traditional hybrid composites that allow them to be “packed” in a manner that somewhat resembles amalgam placement. As there is increased viscosity and resistance to packing, some lateral displacement of the matrix band is possible. Two objectives drove their development: a more straightforward proximal contact restoration and a closer resemblance to amalgam's handling characteristics. They do not completely accomplish either.[11]

Flowable composite

Flowable composites are low viscosity materials with particle sizes and distributions that resemble those of hybrid composites, but with less filler. As the amount of resin increases, the mixture's viscosity decreases. This composite has a wide range of clinical applications because it was created with particular handling characteristics in mind. 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 are easy to use, favorable wettability, and handling properties. They are indicated in 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. Essentially "thinned down" composites, flowable composites have fewer filler particles in the resin. Flowable composites are the most promising materials for aesthetic restorative procedures in the future, according to a systematic review by Baoudi K et al. (2015). These materials will prove to be highly useful in a variety of aesthetic restorative procedures..[12]

Ceromers

It is marketed under the name Targis and is an indirect composite material. It consists of a fiber-reinforced composite framework material mixed with ceramic optimised polymers, or certomers. Ceromers are a hybrid material that combines the benefits of advanced composites and ceramics. Ceromers are composed of specially developed and conditioned five-particle ceramic fillers of submicron size (0.04 and 1.0 mm) which are closely packed (approximately 85 wt percent) and embedded in an advanced temperable organic polymer matrix. Ceromers combine the benefits of ceramics and composites: low degree of brittleness, susceptibility to fracture, easy final adjustment, excellent polishability, abrasion resistance, high stability, long-lasting aesthetic quality, and the ability to repair dental restorations. Ceromer restorations not only preserve tooth structure but also look good. Furthermore, the stability of these restorations is ensured by adhesive cementation using cutting-edge luting composites.[13]

Ormocers

Ormocres are organically modified ceramics. It was developed by Fraunhofer Institute for Silicate Research. Ormocers were introduced as a dental restorative for the first time in 1998. These materials are also used in electronics, microsystem 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 networks. Ormocers consist of three components – organic, inorganic portions, and polysiloxanes. The mechanical, thermal, and optical properties of the material can be impacted by the ratios of these constituents. Multifunctional coupling agent silane molecules bind the inorganic components to the organic polymers. The organic part of the methacrylate groups forms a three-dimensional network following polymerization. It benefits from having a superior marginal seal. The monomer molecule's large size reduces polymerization shrinkage.[14]

Fiber-reinforced composite

It is made up of fibre material bound together by a matrix of resin. These are structural materials with a minimum of two district constituents: the surrounding matrix, which provides workability and supports the reinforcements, and the reinforcing component, which gives strength and stiffness. The most popular materials used in dental applications are polymeric or resin matrices reinforced with carbon, glass, or polyethylene fibres. It has superior strength and good overall mechanical properties. It has noncorrosive properties. It has potential translucency along with radiolucency. It has good bonding properties as well as good flexural strength.[15]

Nanocomposite

Advanced dental materials can be manufactured using nanotechnology. Molecular engineering and nanotechnology are other names for nanotechnology. It entails using a variety of physical or chemical techniques to produce functional materials and structures that fall between the range of 0.1 and 100 nm. 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 two new types of nanofiller particles: nanomeric or NM particles and nanoclusters. Nanomeric involves monodisperse nonaggregated and nonagglomerated silica nanoparticles. Aqueous colloidal silica sols were used to create dry powders of nanosized silica particles with diameters of 20 and 75 nm. The dental nanocomposite system retains physical characteristics and resistance comparable to several hybrid composites, while exhibiting high translucency, high polish, and polish retention similar to microfills. The strength and esthetic properties allow to use the resin-based nanocomposite for both anterior and posterior restorations. It has advantages of improved mechanical characteristics, good thermal stability, corrosion resistance, increased transulency, and improved handling properties.[16]

Antimicrobial composite

Introduction of agents such as silver or one or more antibiotics into the material and 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.

Stimuli-responsive composite

Stimuli-responsive materials have properties that can be significantly altered in a controlled manner by external stimuli. Temperature changes, mechanical stress, pH, moisture, and electric or magnetic fields are examples of such stimuli. These composites are used to treat secondary caries in the posterior teeth and have proven to be extremely effective.

Self-healing composite

Materials typically have a limited lifespan and degrade as a result of various physical, chemical, and biological stimuli such as external static (creep) or dynamic (fatigue) forces, internal stress states, corrosion, dissolution, erosion, or biodegradation. This eventually leads to material structure deterioration and, ultimately, material failure. Epoxy resin composite was one of the first self-repairing or self-healing synthetic materials, with some similarities to resin-based dental materials. 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 filed by resin and reacted with a Grubbs catalyst dispersed in the epoxy composite, which results in polymerization of the resin and repair of the crack.[17]

CONCLUSION

It is achievable that one day we will have restorative materials that will mimic the tooth structure they are used to restore thanks to new developments in dental materials science and technology. It is advisable to select the restorative material that best fits the needs of the paediatric patient from the range of options available.

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