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Review Article

Recent advances and research in aesthetic restorative materials

Satyam Jaiswal[1,*], Hemant Vagarali[1], Madhu Pujar[1], Nikita Kapshe[1]

[1] *Dept. of Conservative and Endodontics, Maratha Mandal Dental College, Belgaum, Karnataka, India*

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ABSTRACT

Esthetics can be described study of the beautiful, it objectives beauty and elicits pleasure. Esthetic materials can be described as those that closely mimic the tooth structure. There are large number of aesthetic material that have become available in the market. The variety of restorative options accessible to clinicians has changed spectacularly over the period of last 30 years. In 1981, the materials decisions to be made by a new dentist were very dissimilar than what they are nowadays. A progressively more mystifying array of potential new materials has now seen a way into the market. The dentist must decide material of choice for a particular case without relying on the claims the manufacturer promises.

This review article emphasizes on the newly introduced materials such as Ormocers, Cention N and Zirconomers, and materials which are under research, and may see an introduction into the market in the near future for e.g. an antibacterial composite and a Glass ionomer cement incorporating bioactive glass, their advantages over the traditional predecessors and their properties.

1. Introduction

Face has been, an impression of fullness of life, and mirror of soul. The loss of teeth, can affect facial appearance. The word “esthetics” was first used in 1750 for the science of sensuous knowledge, which meant beauty, in contrast to the science of logic, which gave truth. It is a derivative of a Greek word “Aesthesis”. Glossary of Prosthodontic Terms, defines esthetics as pertaining to the study of beautiful. It objectifies beauty and attractiveness and elicits pleasure. Third New International Dictionary of Webster has also defined esthetics as aware of, responsive to or zealous about the beautiful; having a way of beauty or fine culture.[1]

A progressively more mystifying array of potential new materials has now become seen a way into the market. To establish the value of a awfully branded restorative material without being misled by its anticipated qualities by the brands is a challenge that dentists all over the world must accept.

2. Evolving Aesthetic Dental Materials

The variety of restorative options accessible to clinicians has changed spectacularly over the period of last 30 years. In 1981, the materials decisions to be made by a new dentist were very dissimilar than what they are nowadays. The direct restorative materials included plastic capsules of amalgam that were triturated together and a box of composite materials that involves paste A and B that were to be mixed simultaneously into a preparation prior to its polymerization.[2]

The method of Shade selection and layering was too futuristic in those days. At that time dentists had only a “universal shade” that was advocated for 75% of the anterior fillings performed. Patient expectations were diverse at that time and so was the definition of esthetics for them..[2]

3. Indirect Restorations

The indirect porcelain technology evolved at a moderately disciplined pace. A ambitious community of patients greatly enhanced the rate of growth, beginning in the mid-1990s,

* *Corresponding author*.
E-mail address: satyamj305@gmail.com (S. Jaiswal).

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as the dental experts wanted a bio-identical restoration that could imitate the optical metamerisms of natural teeth.[2]

Ceramics came into dentistry in the late 18th century when dentists came to know that the porcelain could be used to fabricate denture teeth that could be hollowed out and fixed to teeth to make jacket crowns. Even though porcelain (i.e., all-ceramic) jacket crowns show a high aesthetic level, it is lacking in strength (50 MPa) that causes it to chip off easily.[2]

However, it is seen that using PFMs in the aesthetic zone presents its own drawbacks by not allowing definite light characteristics, like translucency and diffraction. In the 21st century dentists must decide on a material aspect by decisive relative importance of a number of factors, inclusive of strength, conservatism, and aesthetics.

Anterior aesthetics is a driving force in dentistry. "one size fits all" mentality should not be there when diagnosing and treating patients. Answerable aesthetics can be only derived from a relentless pledge on behalf of the technicians of laboratory and the clinician to offer a restoration that looks accepted, but that also compliments the sanctity of the tooth structure remaining in the process.[2]

4. Direct Restorations

Acrylic resins were succeeded by silicate cements in the ides of the 20th century as the solitary aesthetic material in dental practise

In the 1970s, composites arose to replace acrylic resin, the initial microfill composites were created in the 1980s.[2]

In the 1990s, a additive features of composite and bonding technology began to press forward composite use. Starting with microhybrids, nature of particle, content was produced in terms of structure, size, load, and chemical nature of particles. Capacity of diffraction began to be differentiated, and methods to layer various composite materials to impersonate the nuance of tooth structure came into being.[2]

In dental practise smart materials has turned heads and received lot of attention in past few years. Conventional glass ionomer has various applications. Glass ionomers differs in translucency. Glass Ionomer are biocompatible with the dental pulpal tissues. Initially it was used as a biomaterial to replace the lost bony tissues in the human body. Mainly made up of glass and an organic acid, glass ionomers can be used to achieve an aesthetic result, but their aesthetics cannot match that of composites.[3]

GIC was produced for the first time in late 1960s by Alan Wilson and his colleagues in a laboratory located in London.

Acrylic resin came into existence in dentistry in the mid 1950s. Since then, acrylic based materials have played a vital role in prosthetic and restorative field. The potential for greater application of resins came about with the introduction of the bisphenol A glycidyl methacrylate, or BIS-GMA, by Bowen in the early 1960s. This composition had a higher molecular weight and consequently mechanical properties were better and this caused reduction in polymerization shrinkage, the newer polymer has a better chance for much greater applications that included anterior and posterior composite cavities, indirect restorations, sealants for pit and fissure and more wear resistant denture teeth.

Although Bowen's formulation has been available for more than 30 years, the chemistry has remained relatively unchanged. As a result, the mechanical properties also have not improved substantially.[4]

5. Recent Advances and Research in Newer Aesthetic Material

5.1. GIC

Modifications in the composition of GICs have been tried to outperform older versions of gic, particularly in the powder part., reactive glass fibers, and other nonreactive fillers Metal powders have been clinically tested to get improved the mechanical properties of GICs with no loss of their adhesive and fluoride releasing properties, on the other hand, the initial modifications were devoid in the bonding linking the reinforcing filler and the GIC matrix. lately, there have been momentous changes and modifications in formulations of the acidic and basic constituents of the GICs, improving mechanical and handling characteristics of the material. It is thought that by ever-increasing the amount of polysalt bridge formations and cross-linking inside the matrix of the set cement, the mechanical properties of GICs may be improved, which in turn, would make them a correct choice for posterior restorations.[5]

5.2. Bioactive glass reinforced glass ionomer cements

GICs bioactivation aim to improve their mechanical properties. GIC bonding is chemical with enamel, dentin, and bone by the dealings of the aqueous polyacid with the apatite of these hard tissues, GIC can be considered bioactive. The primary commercial bioactive GIC consisted of 46.1 mol% silica (SiO2), 24.4 mol% Na2O, 2.6 mol%P2O5,and26.9mol% CaO and was called 45S5 or Bioglass. Relying on the composition of BAG, the hybrid GICs have displayed antimicrobial properties.

The compressive strength reduce with the amplification of BAG content. The cGIC-BAG materials have average 55% higher surface microhardness than compared to the RMGIC-BAG. The quantity of release was considerably higher on all RMGIC-BAG, being the maximum on RMGIC-BAG along with 30wt% of BAG after 180 days of immersion.[6]

5.3. Reinforced glass ionomer cements (Reactive glass fiber)

Abundant studies have emphasized on the consequence of incorporation glass fiber on the mechanical properties of GICs, exclusively fracture toughness and strength. Lohbauer et al. studied the fracture toughness and total energy discharge of a fiber reinforced glass ionomer for dental purpose consisting of 20 vol % short fibers(430 mm). An improvement in fracture toughness of 140% and total energy release rate of 440% was achieved when compared to the unreinforced GIC.[6]

5.4. Hydroxyapatite (Ca10(PO4)6 (OH)2) reinforced glass ionomer cements

Even though GICs have superior biocompatibility, numerous attempts have been made to add in extra biologically active glasses. Hydroxyapatite appears to hold biological behavior that is dazzling; its composition and crystal structure are similar to those of the apatite found in human dental structures and the skeletal system. The nano-hydroxyapatite crystals can help in remineralization of enamel, and it has been recommended that the superior mechanical properties of apatite-modified GICs are the consequence of ionic interaction sandwiched between the polyacrylic acid and the apatite crystals. The nanohydroxyapatite and fluoroapatite added cements exhibit superior compressive strength (177–179 MPa), elevated diametral tensile strength (19–20 MPa) and higher biaxial flexural strength(26–28 MPa). GICs that contain nanobioceramics shows potential as a restorative dental materials together with improved mechanical properties and bond strength to the dentin.[5]

5.5. Glass ionomer reinforced with Silica cements

Many scientists have added to GIC, SiO2 in an effort to improve their mechanical properties. Trial has been made to use SiO2 based reinforcing agents in the skeletal configuration of the GIC to add to the number of polysalt bridges in the glass matrix and to get better transparency.[5]

5.6. Zinc-based glass ionomer cements

Aluminum is present in the glass phase of all available GICs and it has restricted their extensive use in orthopedics, as aluminum is alleged to cause defective bone mineralization, thus hindering the development of a stable bond between GIC and bone. Nevertheless, the aluminum ion plays an essential role in the setting process of a GIC, and its lack can hinder cement formation. Luckily, zinc oxide can togetherly act as a network modifying oxide and an intermediate oxide in a similar fashion to alumina.[5]

5.7. Hydroxyapatite and zirconia reinforced glass ionomer cements

Due to their good dimensional stability and toughness Zirconium and its oxide, have been used extensively to toughen and strengthen brittle Hydroxyapatite bioglass in medical applications. It has been seen that the hardness amplifies with an increase in the content of nano-zirconia up to 5% and then decreased on further addition.[5]

5.8. Glass ionomer cement incorporating Niobium pentoxide

Niobium pentoxide is a metallic oxide usually showing a monoclinic form well-known to augment the mechanical properties when integrated in metal alloys and shows biocompatibility and bioactivity. Bertolini et al. formulated a glass structure based on the 4.5SiO2 –3Al2 O3 –Nb2O5 −2CaO composition with an aim to use these as GIC complex formers. The results have shown that the setting time of the cement pastes increases with an increase in Niobium content of the GIC. In disparity, the mechanical properties were negatively affected.[7]

6. Composites

6.1. Recent advances in composites (Bioactive composites with antibacterial and remineralizing properties)

The composition of composite and characteristics have significantly improved, yielding longer lifetimes. Nevertheless, recurrent caries alongside the tooth-composite interfaces remains a major cause for malfunction and substitution of restorations.

Contributing factors to composite restoration failures include

1. Composites are prone to gather more bacterial biofilms than other restorative materials. The percentage of streptococci mutans in total colony-forming units (CFU) count in plaque was greater on composite (mean 13.7) and amalgam (mean 4.3) than on glass-ionomer (mean 1.1) restoration. Composite resin naturally augment bacterial growth. There is a probable impact of composite resins on the ecology of microorganisms in the dental plaque biofilm" due to an amplified biofilm gather on composites.

2. The composite-tooth bonded boundary is the frail link of the restoration, frequently forming microgaps and allowing microleakage over a period of time in vivo, providing a spot for bacterial incursion that may lead to recurring caries.[8]

To prevail over these troubles, effort have been dedicated to developing a new generation of bioactive dental materials

7. Rechargeable Composite and Adhesive with Long-Term Calcium Orphosphate ion Release

A chief disadvantage of CaP composites is that the Ca and P ion release lasts for only weeks to months, and then decreases over time. Nevertheless, to have realistic implications in vivo, the CaP-containing restoration requires to be effective for much longer than a few months and, in fact, must persist to release Ca and P ions to curb enamel and dentin demineralization for many years. Thus, it would be extremely advantageous for the CaP composite to be able to continually recharge and re-release Ca and P ions, thus providing these ions for an indefinite period with long-term caries-inhibition ability. Recently, an experimental rechargeable CaP dental composite has been developed.

In addition, a rechargeable CaP bonding agent was also developed with the function of subsiding recurrent caries at the bonded tooth-restoration junction. The Ca and P ion release from the adhesive resin remained high and did not decline with increasing the number of renewal and re-release cycles. After the third recharge cycle, specimens with no additional recharge showed a nonstop Ca and P ion release for 2 to 3 weeks. Consequently, it seemed to be likely to recharge the restoration just the once per week to have continued ion re-release for at least a week. These outcome established the potential for continued Ca and P ion release for an NACP nanocomposite and NACP adhesive to potentially accomplish a lasting caries-inhibition capacity.[8]

8. Antibacterial Dental Composites and Bonding Agents

Dental caries is a frequent bacterial infection in humans and is a nutritional carbohydrate-modified bacterial disease. Demineralization of tooth is caused by acid formed by bacterial biofilms in the company of fermentable carbohydrates. One way to this problem has been the development and blend of antibacterial quaternary ammoniummethacrylates (QAMs)and their integration into resins for use in dentistry Ground-breaking work by Imazato and associates yielded MDPB, which could be copolymerized and covalently bonded in the resin matrix, therefore becoming unmovable to provide extended contact-inhibition against oral bacteria. A commercially available MDPB containing bonding agent, Clearfil Protect Bond, has shown to have strong antibacterial activity against S mutans, Lactobacillus casei, and Actinomyces naeslundii, and was able to eliminate remaining bacterial inside dentinal tubules of prepared tooth cavities. Numerous additional antimicrobial formulations were also developed, including a methacryloxylethylcetyl dimethyl ammonium chloride containing adhesive, quaternary ammonium polyethylenimine, nanoparticles for, antibacterial nanocomposites antibacterial glass ionomer cements, antimicrobial dental composites and bonding agents using a quaternary ammonium dimethacrylate.[8]

9. Cention N

Cention N (Ivoclar, Vivadent) is comparatively a newly launched tooth-colored, essential filling material for bulk filling of restorative material in preparations that are retentive similar to tooth preparations done for conventional amalgam restoration, with or without the use of an adhesive (Ende, 2017). These are “alkasite” group of restorative materials which is a fresh category of filling material, like compomer or ormocer and is basically a subgroup of the composite resin. Cention N is, self curing powder/liquid restorative material with an optional additional light-curing. It is UDMA based. The liquid principally is composed of dimethacrylates and initiators, while the powder is composed of various glass fillers, various initiators and numerous pigments. They are radio opaque and consist of alkaline glass fillers that are capable of releasing ions such as fluoride, calcium and hydroxide. Due to the cross-linking of methacrylate monomers in blend with a essentially stable, and efficient self cure initiator, Cention N has shown to display a higher polymer network density and degree of polymerisation over the complete depth of the restoration meticulously.[9]

A unique property of Cention N is its special patented filler (Isofiller) which acts as a shrinkage, stress reliever and due to its low elastic modulus this shrinkage stress reliever within.[9]

10. Zirconomers

With the decline in popularity of amalgam in recent years, there is a need for an equally strong yet safer replacement. Zirconomer is relatively a new class of restorative Glass Ionomer that promises the strength and toughness of amalgam with the exclusive benefits of Glass Ionomer while completely eliminating the hazard of mercury. The zirconia fillers that are included in the glass component of Zirconomer strengthens the structural reliability of the restoration and gives it superior mechanical characteristics for the restoration of posterior stress prone areas where the conventional restoration of choice is amalgam. Advantageous properties such as marvelous strength, long lasting and sustained fluoride protection makes it ideal restorative material for restoration in posterior teeth, in patients with high caries frequency as well as cases where strong structural cores and bases are required.

11. Ormocers

In an endeavor to prevail over several of the drawbacks and concern related with the traditional composites, a innovative packable restorative material was in launched called Ormocer, an acronym for organically modified ceramic technology.[10]

These are materials that consist of inorganic and organic co-polymers in association with inorganic silanated filler particles that are present. It's formulated via solution and gelation process, from multifunctional urethane and thioether(meth) acrylate alkoxy silanes. Even prior to light curing for the polymerization the matrix of ormocer is a chiefly a polymer. They are comprised of ceramic polysiloxane essentially, which has shown lower shrinkage as compared to the matrix of organic dimethacrylate monomer that is witnessed in composites. Ormocers are generally described as cross-linked copolymers which are three dimensional in nature.

The studies and research work carried out extensively on properties of ormocer filling materials, have shown that they are an apt alternative for direct aesthetic restorations or should we announce the arrival of ormocers in this period and are here to stay.[11]

12. Conclusion

The demand for aesthetic materials that appear tooth like have increased in recent times. The desire for aesthetic restorative materials have splurged with the advent of ceramic crown, GIC, and composite restorations.

This has led to more research and advances in these materials to overcome the drawbacks and improve the characteristics and aesthetics of these materials. Dental aesthetics is the prime desire of all individuals. Tremendous increase in aesthetic needs in dentistry has led to evolution of aesthetic dentistry insisting for development and research of various aesthetic restorative techniques and materials. The combined efforts of researchers manufacturers and artistic operators have succeeded in creating beautiful smiles. However the demand for improved aesthetics and research in this field is constant.

13. Source of Funding

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14. Conflict of Interest

None.

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Author biography

Satyam Jaiswal Postgraduate

Hemant Vagarali Professor

Madhu Pujar Professor and HOD

Nikita Kapshe Postgraduate

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