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Research Article

RECENT ADVANCES IN RESTORATIVE RESINS- A REVIEW

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A B S T R A C T

The aesthetics have improved because of the high level of biomimetics of these new resin materials, which also allow for a better function within the oral cavity. The correct use of ceramic and composite materials with rigorous adhesive procedures allows sound tissue preservation because of the minimally or even noninvasive (additive) approach, which is innovative, highly esthetic, and predictable in terms of both result and long-term prognosis. This review article focuses on the material aspect of the newer generation of resin materials and summarizes recent developments in resin-composite materials for CAD/CAM applications, focusing on both commercial and experimental materials.

INTRODUCTION

As civilization advanced with development of biological, chemical and physical sciences there occurred a slow but steady increase in both the quantity and quality of useful materials available for restorative dental practice.[1] The correct use of ceramic and composite materials with rigorous adhesive procedures allows a sound tissue preservation because of the minimally or even noninvasive (additive) approach, which is innovative, highly esthetic, and predictable in terms of both result and long-term prognosis. The aesthetics have also improved because of the high level of biomimetics of these new resin materials, which also allow for a better function within the oral cavity.[2]

Composite resins have been introduced into the field of dentistry to minimize the drawbacks of the acrylic resins that replaced silicate cements (the only aesthetic materials previously available) in 1940s. Nanocomposite recently introduced contains only nanomeric particles and nanoclusters as inorganic fillers. It is designed to produce the polish retention of microfill composites and the mechanical properties of hybrid.

Nanotechnology has progressed significantly and particles as small as 3 nm are being employed in resin-based restorative materials to improve clinical performance. The inorganic fillers employed in dental materials may be categorized according to their size range, varying from macro fillers to nanofillers, and their size is controlled either by a top-down or a bottom-up manufacturing approach. The high concentration of surface-free energy causes the nanoparticles to bond strongly to other materials and to each other.[4] CAD/CAM systems have progressed very rapidly in the past 25 years, where a variety of systems has been launched into the market.[5] The materials made for CAD/CAM applications are currently the dynamic field in dental materials. The two types of materials are commonly used in the production of CAD/CAM restorations are glassceramics/ceramics and resin composites. The glass-ceramics/ceramics shows altogether superior mechanical and esthetic properties and the resin composite materials have overall significant advantages related to intra-oral reparability.[6]

Recent Advancements

The Composite resins have been introduced into the dentistry so as to reduce the drawbacks of the acrylic resins.

Direct Resin Composites

Antimicrobial Composite

To introduce antimicrobial properties Silver and titanium particles were incorporated to enhance biocompatibility of the composites. The antimicrobial material leaches out and killed the microbes when come in contacts.[7]

Indication- High caries activity rate.

Advantages

- The slow release of antimicrobial agents added to dental composites used to inhibit or kill oral biofilms that contribute to caries and cause composite degradation.

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Disadvantages

Antimicrobial effect of silver ions incorporated into SiO_2 lasts for only a short period of time and can lead to discoloration of the composite resin.

Self-healing Composites

This composite has the ability to heal them when there is a structure failures due to the microcracks in a material ensures greater lifetime and least maintenance.

Indications

- Reoccurrence of micro cracks in composites.
- To increase reliability and endurance of composites where repairing is not possible at remote locations in the way.

Advantages

- These self-healing materials heal through inherent reversibility of physical or chemical bonding instead of structure design such as the swelling of shape memory polymers, the melting and solidification of thermoplastic material, and increasing viscosities of pH-sensitive micro-gels.
- The maintenance task is quite simplified
- Disadvantages-
- Incorporation of self-healing properties in composites may not accomplish the self-healing task unless not triggered externally.

Self-Adhesive Composites

These composites are also called as compo-bonds. These composites act as shock absorbers beneath the resin-based composite restoration.

Indications

- Minimally invasive cavities.
- Where restoration has to be done in a short period of time such as paediatric patients or medically compromised patients.

Advantages

- Self-Adhesive Composites eliminate the precursory bonding stage which is required to adhere resin to tooth substrate, and reduce the chances of postoperative sensitivity.[8]
- This is the all-in-one bonding system.
- Easy to use and time saving.

Disadvantages

The bond strength of self-adhesive composite resins is lower than that of conventional composite resins.

Fiber Reinforced Composites (FRC)

These fiber reinforced composites exhibited improved strength and stiffness and improved wear resistance. The durability of the FRC mainly depends on 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.

Indications

- FRC material is used in removable dentures, fixed partial dentures, periodontal splints, orthodontic retainers and root canal posts.
- FRC allows minimally invasive long-term restorations, even for multiple tooth replacement.

Advantages

- Fiber Reinforced Composites has more fracture toughness compared to the other materials.
- It provides high strength.
- Disadvantages-
- Gray/ metal shadow due to metal posts and cores or amalgam cores on abutment teeth.
- Loss of surface shining on the particulate veneering composite.
- Excessive translucency in pontic areas.
- Fracture or chipping of the particulate composite veneer.

Ormocers (Organically modified ceramic oligomers)

Ormocers are made up of ceramic polysiloxane, which are capable of decreasing shrinkage as compared to the matrix of organic dimethacrylate monomer that is seen in composites.

Indications

For veneering of discoloured anteriors, repair of veneers, core build-up, orthodontic bonding adhesive, indirect inlays, and reconstruction of traumatically affected anteriors.

Advantages

- They are an apt alternative for direct aesthetic restorations.
- They shows limited cure shrinkage, very high biocompatibility, good manipulation properties, and excellent esthetics.
- The ormocer matrix is not only organic but also inorganic. Therefore monomers are better embedded in the matrix what reduces the release of monomers.

Disadvantages

- Ormocer (DefiniteR) failed to meet the needs for restoration durability compared to conventional composite resin for class II restorations.
- The wear resistance is lower.

Cention N

Cention N is a self-curing powder and liquid restorative material and comparatively a newly launched tooth colored material for bulk filling of restorative material in preparations.

Indication

- Demand in tooth colored restorations, this material of choice can be a cost-effective way to deliver a high-quality, predictable restoration. It consume less time.

Advantages

- They are radiopaque in nature because they consist alkaline glass fillers.
- The Cention N resin-based filling material is easy to do clinically and does not require any special products or learning additional skills.

- Its special patented filler (Isofiller) acts as a shrinkage and stress reliever.[9]

Disadvantages

- It is available in only one shade.

Componeers- It employs a direct veneering technique. These are polymerized, prefabricated, enamel shaded composite laminates and that combine the properties of both direct and indirect veneers. There is conservative removal of tooth structure – 0.3mm cervically and 0.6-1mm incisally. A natural layering concept is followed and developed to allow combination of all enamel and dentin shades. This concept is based on a two layered incremental technique that mimics the anatomy of natural tooth.

Indications

- Tooth fracture, Malformation, Midline diastema, Wasting diseases of tooth, Aesthetic correction and Discolouration.

Advantages

- Superior esthetics and Economical.
- No lab work is required
- One sitting

Contraindications

- Bruxism and Active caries

Compomers

The term 'compomer' was crafted by the producers of the first commercial material of this kind: a polyacid-modified composite resin, sold as a filling material for some specific applications.[10]

They differ from the GIC in at least two respects

First, the glass particles are partially silanized to provide direct bond with the resin matrix, and second, the matrix is formed mainly during the light-activated, radical polymerization reaction of monomers. Those monomers are essentially modified methacrylates, (UDMA, BisGMA, etc.) and new bifunctional monomers containing simultaneously two carboxylic groups and two double bond functions (TCB, DCDMA, etc.).

Indications

- Cervical lesions, Class III restorations
- Restorations in the primary dentition
- Class I and I1 restorations in the permanent dentition

Advantages

- As a result of promising results from preclinical evaluations, compomers have been widely used together with one-bottle adhesives for bonding.
- Despite being less than perfect, the dentin adhesion of these systems seems to be clinically sufficient for omitting undercuts during preparation.[11]

Disadvantages

Compomers have poorer mechanical properties, with a lower comprssive, flexural and tensile strength.

Indirect Resin Composites

In recent years, laboratory processed composite resins have been developed not only for use as restorative materials in fixed prosthodonitcs but also as indirect veneering materials. Using light, heat, vacuum, or a combination therefore, micro filled resin materials can be processed to achieve physical and mechanical properties superior to those of traditional chair-side composite resins. Even though the inorganic filler content is relatively low, ranging from 30% to 50% by weight and the wear resistance of these materials is surprisingly good. Through laboratory processing, indirect resin veneers are more completely cured and do not experience the same in-situ polymerization problems typically encountered during conventional direct composite resin veneering.

Ivoclar introduced the one of the initial material that was SR-Isosit® that uses a hydropneumatic heat cure in the Ivomat® apparatus. Clearfil CR Inlay® (Kuraray) is another example of indirect material which uses heat and light for the indirect technique. Conquest® (Jeneric/Pentron), Dentacolor® (Kulzer) and EOS® (Vivadent) use only heat for additional curing, whereas Visio-Gem® (ESPE-Premiere) uses vacuum and heat for additional curing. It is possible to use any posterior composite for indirect techniques with additional curing.[12]

First Generation Indirect Resin Composites

Their composition was similar to the direct composite resins. Examples are Concept (Ivoclar), SR-Isosit Inlay system, Coltene Brilliant, Dentocolo (Kulzer), and Visio-gem (ESPE).[13]

Drawbacks of First-generation IRCs

- Poor clinical performance
- Poor wear resistance, marginal gap, microleakage
- Inadequate bond between organic matrix and inorganic fillers
- Higher incidence of bulk fracture.

Second Generation Indirect Resin Composites

The research and development of second-generation composites came into role because of the clinical failures that occurred in the first-generation composites and the limitations faced with ceramic restorations.

1. Paradigm MZ100 (3M ESPE) contains ultrafine zirconia -silica fillers synthesized by a patented sol-gel process.
2. Artglass contitues of barium silicate glass filler. It is photo-cured using a xenon stroboscopic light. Crowns, Inlays and Onlays with/without metal substrate can be fabricated using this material.
3. Sinfony launched by 3M ESPE contains fillers which is made of glass-ceramic powders or ultra-fine glass. These uses Visio alpha and Visio beta polymerizing units for polymerization.
4. Belleglass HP made up of silanated microhybrid fillers. Surface and base composites, which are used on enamel and dentin, respectively. The smoothness and polishability of the material are improved by the reduced filler size.
5. SR Adoro (Ivoclar Vivadent) contins dentin and enamel materials as the main component and also has a liner, opaquer, stains, and SR link (bonding agent).

6. Vita Zeta LC (Vita Zahnfabrik) contains multiphase feldspar frits and silicon dioxide filler. High translucent obtained as a result of natural refraction is ensured by the nanofillers.
7. Estenia C and B (Kuraray) composed of glass and alumina ultra fine fillers.
8. Gradia (GC Corp) has silica, silicate glass powder, and prepolymerized fillers.

Indications

- Patients with poor periodontal structures and who require occlusal coverage then stress-absorbing materials like IRCs are indicated.

Advantages

- Indirect Resin Composites reduce polymerization shrinkage and improve the properties of material.
- Additional clinical benefits include ideal proximal contacts, precise marginal integrity, optimal esthetics and excellent anatomic morphology.
- Polymers are most commonly used because they absorb relatively more occlusal stress.[14]

Disadvantages

- Early discolouration rate, complex approach with preparation, impression and luting.

CAD/CAM block materials

The restorative materials such as glass–ceramics/ceramics, composite and acrylic resins can be process by CAD/ CAM technology due to the introduction of new digitalization technologies and tools. [15]

Resin composites

Exp (Glidewell), Paradigm MZ100 (3M ESPE), Lava Ultimate (3M ESPE), Ceramart (GC), Grandio blocs (VOCO), Shofu Block HC (Shofu).

Hybrid Ceramics

Vita Enamic (Vita)

A list of materials used with 3D printing in dentistry grouped by manufacturing technology

Printing Materials Available	Technology
Polyjet printing	Photopolymers
Multi-jet printing	Plastics, ceramics and metals
Fused deposition modelling (FDM)	ABS, polypropylene, polycarbonates
Selective laser sintering (SLS)	Plastics, ceramics and metals
Selective laser melting (SLM)	Metals
SLA / DLP	Photopolymers, plastics and ceramics

Advantages

- Compared to glass–ceramics/ceramics, CAD/CAM composites blocks are easily fabricated and repaired.
- They have better machinability and thus lower tendency to marginal chipping.

Disadvantages

- Composite blocks generally are still not as strong as glass–ceramics/ceramics.

CAD/CAM acrylic Resins

Prepolymerized acrylic resin in blocks for CAD/CAM-

Advantages

- Reduction in surface roughness, and it can be considered a potential alternative to conventional CDs
- It is prepolymerized under specific and standardized conditions; and because of that, it is believed that it has improved material properties when compared to the heat-polymerized acrylic resin for conventional CDs.
- These have potential of reducing the pigmentation and attached microorganisms due to the reduced surface roughness of the prepolymerized resin.

Disadvantages

- It requires access to a digital scanning unit and appropriate milling machine.
- There is a waste of the remaining material after milling the restoration, which can no longer be used

Milled PMMA teeth- The 1-piece milled PMMA teeth should prove more resistant to chipping and tooth displacement.[15]

Advantages

- Increased resistance to dislodgement and tooth loosening
- Vertical dimension while retention is maintained in the horizontal dimension.
- Increased bonding surface area;
- Ease of processing; inexpensive maintenance;
- Improved reproducibility when resurfacing is required

Disadvantages

- These are not wear or stain resistant when compared with commercially available
- Although, the cost of milled PMMA is lower, the increased need for replacement may lead to increased maintenance costs.

Nanotechnolgy

The nanobased restorative composites contain 13–30 wt% of polymerizable organic matrix and 70–87 wt% mixture of different inorganic fillers in addition to a photoinitiator or other curing systems. For resin composites, the incorporated different types of nanofillers aiming to minimize polymerization shrinkage, enhance bioactivity and polishability, while controlling viscosity of materials with higher filler loading. The incorporation of nanoparticles of amorphous calcium phosphate, bioactive glass, or hydroxyapatite into dental adhesives. Nanofillers are also added to the composition of dentin bonding systems to stabilize the hybrid layer via improvement of its mechanical properties. The interaction between two nanoparticles is very strong due to their relatively large surface area, and Van der Waals forces make them prone to cluster with each other.

Nanodentistry- Nanotechnology entered the dental field with advancement in material sciences mainly composites and

bonding agents. Nanodentistry will make possible the maintenance of near-perfect oral health through the use of nanornaterials, biotechnology including tissue engineering and nanorobotics. Oral health and disease trends may change the focus on specific diagnostic and treatment modalities.

Nanorobots- An artificially fabricated object able to freely diffuse in the human body and interact with specific cell at the molecular level by itself. Diameter of about 0.5 to 3 microns and will be constructed out of parts with dimensions in the range of 1 to 100 nanometers. The main element used will be carbon in the form of diamond / fullerene nanocomposites.

Indication

- To simplify lengthy procedures.
- To remineralization of teeth after significant decay.
- In case of tooth hypersensitivity.
- In oral cancers.

Advantages

- Faster and accurate diagnosis of oral diseases with small diagnostic machinery.
- Enhancing properties of root canal sealers, and continuous oral health maintenance using mechanical dentifrobots.
- Reduced span of treatment procedures with faster healing properties.
- Reduced frequency of visits to the dental clinics for patient and less fatigue for the practitioners.
- With the availability of advanced and accurate diagnostic methods, various oral diseases can be treated or prevented at early stages.
- The advent of this technology provides greater patient comfort with minimum patient anxiety, precise selectivity, and controllability of the analgesic effect with complete reversibility of the analgesic.[16]

Disadvantages

- Numerous ethical issues to deal with (social acceptance is necessary).
- Toxicity associated with nanoparticles is harmful to human beings as well as to the environment.
- Subsequent irretrievable genetic information loss that was essential for better prospects of Nano-dentistry and nanotechnology in general.

CONCLUSION

The field of composite resins continues to propose and achieve significant and exciting advances in resin formulation, filler loading and modification, and curing methodologies and mechanisms. While most of the advances discussed herein remain in the research stage, the future both in regards to research and in clinical practice remains bright with exciting new developments translated into practice at an ever-increasing rate. Some of the desirable characteristics of nano-based restorative resin materials are higher mechanical properties, retained polishability and stable optical properties and some level of bioactivity for dental adhesives. Although advancements have been reported in in-vitro studies, the scientific clinical outcomes still fail to demonstrate the superiority of nano-based resin materials. Finally, it should be mentioned that some contraindications exist for every kind of restorative therapy.

Adhesive and minimally invasive dentistry is nowadays a consolidated reality in Prosthetic Dentistry. New materials and techniques must guarantee a good predictability of the final goal from the beginning to the end of treatment and not only an optimal aesthetics, which could also improve. However, other studies with more patients and longer follow-ups are required to prove the reliability of this new tricks and techniques improving the technical procedures of the treatment.

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