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AN INSIGHT INTO PROSTHETIC COMPOSITES

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ABSTRACT
Tooth-colored composite resin fillings are becoming very popular now a days for cavity fillings. It is limited for small cavities in posterior teeth. Besides its wide use and popularity, it has scope for improvement due to polymerization shrinkage and its lifespan. These are problems that may be addressed by using an alternative indirect fabrication and placement restorative procedure. Indirect composites offer an esthetic alternative or supplement to ceramics for posterior teeth in certain clinical situations.

KEYWORDS: Indirect resin composites(IRC), polymerization.

INTRODUCTION
Bis-GMA was introduced by Bowen in 1962, since then many advances have been made to improve the physical properties of composites.Earlier composites were used for anterior restorations only, but after many improvements they have been used to restore posterior teeth also. Polymerization shrinkage is one of the primary limitations affecting the long-term serviceability of direct placement posterior composite resin restorative materials.[1]

Newest direct composite resins offer excellent optical and mechanical properties, their use in larger posterior restorations is still a challenge since polymerization shrinkage remains a concern in cavities with high C-factor. Though there have been numerous advances in adhesive systems, it is observed that the adhesive interface is unable to resist the polymerization stresses in enamel-free cavity margins.[3,4] This leads to improper sealing, which results in microleakage, postoperative sensitivity, and recurrent caries. The achievement of a proper interproximal contact and the complete cure of composite resins in the deepest regions of a cavity are other challenges related to direct composite restorations. Various approaches have been developed to improve some of the deficiencies of direct-placement composites.[5,6] However, no method has completely eliminated the problem of marginal microleakage associated with direct composite.[4,7] IRCs were introduced to reduce polymerization shrinkage and improve the properties of material.

Types of IRCS
Restorative resins can be divided into direct and indirect resin composites(IRC). IRCs are also known as *prosthetic composites or laboratory composites.* These are used for large posterior restorations.In 1980s, Touati and Mörmann introduced the first generation of IRCs for posterior inlays and onlays.[2] Direct resin composites mainly consists of organic resin matrix, inorganic filler, and coupling agent. Also the first generation IRCs have the same composition.

A direct–indirect / semi-indirect method or an indirect method was used to fabricate the restoration with the first generation composites.[3]

Direct method
In direct method, separating medium is applied to the cavity walls and then the composite material is condensed into the cavity. After the initial intraoral curing, the restoration is subjected to extraoral light or heat tempering in an oven. This is a single sitting method and eliminates the need for an impression.[3] DI-500® Oven (Coltene Whaledent) or a Cerinate® Oven (Den-Mat Corp) can be used at 110°C for 7 min. Brilliant DI® (Coltene Whaledent) and True Vitality® (Den-Mat Corp) are examples of material that uses both light and heat for this technique.

Indirect Method
In this method, a die is used for the fabrication of an inlay. The material is condensed in the cavity in increments. It is first light cured and then heat cured in an oven at 100°C for 15 min. The difference between direct and indirect is only that the inlay is fabricated in a die rather than the cavity. The advantage of this technique is that the proximal contours can be achieved appropriately. Few of the indirect materials are SR-Isosit®, Clearfil CR Inlay® (Kuraray), Conquest®

(Jeneric/Pentron), EOS® (Vivadent), and Dentacolor® (Kulzer).[3]

PROPERTIES OF FIRST-GENERATION COMPOSITES

Various studies have been conducted to determine the properties of first generation composites. Flexural strength of the first generation composite ranges from 10–60 MPa and elasticity modulus ranges from 2000–5000 MPa.[4-7]The degree of conversion increased by 6%–44%. The degree of conversion is influenced mainly by the post cure temperature. However the duration does not make any marked difference as demonstrated by different studies.

Disadvantages

The first generation composites showed high incidence of bulk fracture, marginal gap, microleakage, and poor clinical performance. Different measures taken to solve these problems included increasing of inorganic filler content, reduction of filler size, and modification of the polymerization system.

SECOND-GENERATION INDIRECT RESIN COMPOSITES

The second generation composites were developed to overcome the limitations of the first generation. The changes were done in structure and composition, polymerization technique, and fiber reinforcement.[9]

Structure and composition

Unlike the first generation composites that were microfilled, the second Generation were composed of 'microhybrid' filler with a diameter of 0.04–1 µ. The filler content was also increased to twice which helped to improve the mechanical properties and wear resistance. The polymerization shrinkage is reduced by reducing the organic resin matrix.[3] Composites like Artglass® and belleGlass HP® are adequate for restoring posterior teeth as they contain high amount of filler content and those with intermediate filler loading such as Solidex® (Shofu Inc.), are preferred for anterior tooth.[8, 9]

Polymerization techniques

Even additional light curing extraorally did not efficiently improve the degree of conversion. Thus, for the polymerization of second-generation IRCs various specific conditions like like heat, vacuum, pressure, and oxygen-free environment are utilized. The various techniques used for additional cure are described below.

Heat polymerization

After the initial light curing, heat can be used for additional curing. The temperature used ranges from 120–140°C. The heat can be applied in autoclaves, cast furnaces, or special ovens.[11]This process of post cure heating decreases the amount of unreacted monomer. The residual monomer covalently bonds to the polymer and the unreacted monomer is volatilized by heat curing. By using this method of using heat and light, the wear resistance increased by 35%.[12]

Soft start

This method of polymerization is based on the fact that faster rates of polymerization result in premature rigidity and increased stiffness, so slow rates should be used. They allow better polymerisation. This concept of slow curing was described by Mehl[12] and is incorporated in the curing process for both belleGlass® and Cristobal®.

Fiber reinforcement

This method utilizes different types of fibres in order to reinforce the composite. These fibres act as crack stoppers. The most commonly used are the glass and polyethylene. These fibres can be arranged in different directions for reinforcement. Fiber-reinforced composites were introduced by Smith in the 1960s. Polyethylene fibers,[13] carbon/graphite fibers, Kevlar®, and glass fibers[14-16] were tested. Glass and polyethylene are the commonly used fibers in dentistry. Fibers act as crack stoppers and enhance the properties of composite. The resin matrix acts to protect the fiber and fix their geometrical orientation.[17,18] The fibres are kept perpendicular to the applied forces for strength reinforcement.[19] whereas the multidirectional reinforcement is accompanied by a decrease in strength in any one direction.

Nitrogen pressure

It is used to eliminate the internal oxygen before the material begins to cure. Oxygen present in air inhibits the process of polymerization and also plays an important role in the apparent translucency or opacity of the cured resin restoration. This elimination of oxygen affects the degree of conversion, esthetics, wear, and abrasion.[20] This method of curing is employed in BelleGlass® and Sculpture Plus®.

Electron beam irradiation

Electron beam irradiation is another method described for improving the composite's properties.[21] This methodology is used with polymers like polyethylene, polycarbonate, or polysulfone. The two main reactions that occur when a polymer is subjected to electron beam irradiation are chain breakage and chain linkage. When breakage of chains occurs at the region of entanglement, there is induction of dense packing. This influences the bond between the filler and matrix, thus improving the mechanical properties and increasing success rates. The possible disadvantage of this method is polymer degradation and discoloration of the resin.

Fiber reinforcement

Fiber-reinforced composites were introduced by Smith in the 1960s. Glass and polyethylene are the commonly used fibers in dentistry. Fibers act as crack stoppers and enhance the proprety of composite. The resin matrix acts to protect the fiber and fix their geometrical orientation.[22] Boron oxide, a glassforming agent is present at 6–9 wt% in E-fibers and <1 wt% in S-fibers. E- and S-fibers are the ones most commonly used in dentistry.[23]

The fibers can be arranged in one direction (unidirectional), with the fibers running from one end to other in a parallel fashion. Alternatively, the fibers can be arranged in different directions to one another, resulting either in a weave- or mesh-type architecture.[22] When the directional orientation of the fiber long axis is perpendicular to the applied forces, it will result in strength reinforcement. Forces that are parallel to the fiber orientation will produce matrix-dominated failures and consequently yield little reinforcement. Multidirectional reinforcement is accompanied by a decrease in strength in any one direction when compared with unidirectional fiber.

PROPERTIES OF SECOND GENERATION IRCs

Mechanical properties

The flexural strength ranges from 120 -160 MPa and the elastic modulus ranges from 8.5–12 GPa. These materials show better better marginal adaptation than ceramics because of lower polymerization contraction.[25]

Wear of composite resin materials has been evaluated in terms of two main clinical components: occlusal contact/ attrition wear and contact free/abrasive wear. Filler size, volume, shape, and bonding to matrix affects wear. The chemical treatment of filler to increase bonding to matrix decreases wear.[24] Bayne *et al*. studied the wear rates and proved that the wear of Concept® was less than that of belleGlass®. This could be due to the use of microfillers and the small particle size and the interparticle spacing, which resists wear.

Optical properties

One of the problems associated with composite materials is the unpredictable color stability. The mode of curing and the remaining double bonds may influence the color stability of the material.

Marginal adaptation and microleakage

Aggarwal *et al*. observed that marginal adaptation and bond strength of an indirect resin system after thermocycling was better than that after direct restoration. IRCs shows better marginal adaptation than ceramics because of lower polymerization contraction. The refractory die is fractured to remove the ceramic inlays and this may result in marginal microfracture, thus increasing the marginal gap.[25]

Surface properties

The major drawback of the IRC is the formation of secondary caries due to plaque accumulation. The biofilm accumulates on the surface based on the filler size and matrix monomer which is increased by the surface roughness of the material. In order to overcome this problem smaller filler particles should be used and he surface must be smoothened.

Surface treatment of IRCs to improve adhesion

a) Use of hydrofluoric acid to produce the microstructural alterations
b) Sandblasting with aluminium oxide particles for 10 sec.
c) Application of silane after sand-blasting resulted in higher bond Strength.

CONCLUSION

The IRCs are widely used now a days and they can supplement the use of ceramics in different clinical conditions. They are a good treatment choice and show good results according to both in vivo and in vitro studies. However still further research and studies are required to assess these materials in terms of survival.

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