Indirect Resin Composite Restorations- A Narrative Review

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Abstract

Esthetic dentistry is a global phenomenon that continues to grow and expand over the past 30 years many have called it a revolution, but this denotes sudden monumental change. In today’s world looking good is a prime concern. Appearance is closely linked to social acceptance and professional success. Newer technologies are being harnessed for this purpose and advanced research is being undertaken. The focus of dentistry in the present times is not only on prevention and treatment of disease but on meeting the demands for better esthetics. Thus, dentistry has evolved from a curative to a creative science in a very short span. Esthetic dentistry is emerging as one of the most progressive and challenging branches of this field. A deeper understanding of this subject is required to bring out its complete clinical potential. The practice of esthetic dentistry must be based on ethical principles with a holistic approach towards total dental health rather than mere cosmetic considerations. Due to polymerization stresses, the use of direct composite restoration in posterior teeth is limited to relatively small cavities. Indirect resin composites offer an esthetic alternative to ceramics restoration.

Keywords: Composites; IRC; Polymerization shrinkage

Abbreviations: IRC: Indirect Resin Composites.

Introduction

Dental restorative composite materials are classified into direct and indirect composites. Due to the limitations of the direct resin composites, indirect resin composites (IRC) are developed. The other names of indirect composites are laboratory composites or prosthetic composites. IRCs are restorations that are fabricated outside the oral cavity. Most of the IRCs are made on the removable dies of the prepared tooth inside the laboratory. IRCs replace various restorations. IRC gives
an esthetic substitute to ceramic materials for the posterior tooth [1, 2].

**Characteristic Features of IRC**

**Polymerization shrinkage:** Methacrylate is the material which causes polymerization shrinkage. It results in gap formation and micro leakage of the restorations. The use of direct composite in the larger posterior restorations remains a challenge because of the polymerization shrinkage. Logurecio et al in 2004 and Thonemann et al in 1999 observed that direct composites could not resist the stresses due to polymerization in margins of enamel free cavities [3, 4]. Thonemann et al in 1999 stated that the issue of marginal leakage had not been eliminated by any methods in direct composite. Studies have shown that polymerization shrinkage is less in indirect composites when compared to the direct composite restorations. It is due to the curing mechanisms. It includes light, heat, pressure which takes place outside the oral cavity.

**Degree of polymerization:** The main disadvantage of direct composite restoration is that it doesn't undergo chemical action completely. With the additional curing using heat, light, pressure, etc., employed with indirect composites, it tremendously reduces the polymerization shrinkage. The degree of conversion of direct composite resin ranges from 55% to 65% and is higher than the direct composites [5]. The superior properties are due to the complete dual curing methods which are the characteristic feature in the indirect composite restorations.

**Depth of cure:** Effective cure of composites in deeper layers of a cavity is questionable since the light source cannot adequately cure composite resins at a depth of more than 4 mm. More studies are needed to identify the effective curing capacity of composites in deeper layers.

**Contacts and contours:** Establishing a correct proximal contour and ensuring a firm contact with the adjacent tooth in direct restorations is a challenge. Indirect composite restorations provide excellent proximal contacts and contour since the fabrication is done outside the oral cavity, which makes it superior from the direct composites.

**Wear:** Direct composite restorations exhibit excessive wear in areas of high occlusal stress. The major cause of clinical failure of the direct restoration was due to poor wear resistance [6, 7]. Some of the above-mentioned problems can be overcome by curing the composite resin extra-orally with the help of secondary/additional curing using light, pressure, vacuum, heat, inert gas, or a combination of these methods resulting in a dense well-cured restoration. Such restorations can be finished and polished better and can then be cemented to the prepared cavity resulting in a dense well-cured restoration. The physical properties of such restorations are greatly improved.

**Disadvantages of IRC Restorations**

**Expensive:** There is additional laboratory cost involving impression and temporization leading to increased expense to the patient.

**Increased Tooth reduction:** Indirect restorations may require more tooth reduction as compared to direct composites to create a path of insertion and removal. It is mainly due to the divergent tooth preparation and other tooth preparation reduction requirements.

**Difficult for alteration:** It is difficult to modify or add extrinsic color at the chair side. The indirect composites are manufactured in the laboratory. It is luted in the patient's mouth, after the finishing and polishing procedures. So, it is hard to modify the indirect restorations at the chair side.

**Luting:** The thin layer of luting resin cement is liable for shrinkage at the tooth–restoration interface. The polymerization shrinkage is reduced in indirect composites because it requires additional polymerization due to dual curing methods. The luting resin cement which is applied during the luting procedure is responsible for the polymerization shrinkages.

**Indications of IRC**

1. Laminate veneers.
2. Inlays and onlays.
4. Implant supported restorations.
5. Full coverage crowns.
6. Patients with bone loss.
7. Patients with poor periodontal support requiring occlusal coverage.
8. Fiber-reinforced bridges or retainers.

**Contraindications of IRC**
1. Patients with parafunctional habits.
2. Inability to isolate the working area because luting of IRC is technique sensitive.
3. Teeth with heavy wear and tear due to TMJ and occlusal disharmony.

**Classification of IRCs**

A. **Classification based on the generations and type of fillers**

1. **Based on generations**
   a. 1<sup>st</sup> generation materials
   b. 2<sup>nd</sup> generation materials
   c. Next generation materials

2. **Based on type of fillers**
   a. Micro filled composite
   b. Fine hybrid composite
   c. Coarse hybrid composite

B. **Classification based on fabrication method**
   a. Direct-indirect method /semi-indirect method
   b. Indirect fabrication method.

C. **CAD-CAM**

**1<sup>st</sup> Generation IRC’s**

1<sup>st</sup> generation IRCs were first introduced by Touati et al and Mormann et al in 1980. The composition was similar to that of the direct composite resin. Examples are SR Isosit inlay system, Coltene Brilliant, Visco-gem.

**Disadvantages of 1<sup>st</sup> generation IRCs**

The main disadvantages of the 1<sup>st</sup> generation IRCs include low clinical performance and in vitro performance, inadequate bonding between organic matrix and inorganic fillers, unacceptable resistance to wear, bulk fracture, polymerization shrinkage, marginal gap and microleakage. It can be reduced by increasing the size of fillers, and altering polymerization mechanism.

**II<sup>nd</sup> – Generation IRCs**

The clinical drawback of the 1<sup>st</sup>- generation composites prompted the advancement of the enhanced II<sup>nd</sup>- generation composites. The enhancements mainly happened in structure and polymerization methods, composition, and fiber reinforcement.

1. Micro hybrid filler.
2. Diameter of 0.04-1µ.
4. Improved mechanical properties.
5. Improved wear resistance.

High filler content enhances the mechanical features of indirect composites. Artglass and Belleglass HP comprise of excessive quantity of filler content. This makes them appropriate for the posterior teeth restoration. Solidex incorporates intermediate filler content. This property facilitates for better esthetics. These kind of indirect composites are favored for anterior teeth restoration. The commercial names of II<sup>nd</sup> generation IRCs are as follows:

2. Belle glass HP by Belle de St. Claire – 1996.
3. Sinfony introduced by 3M ESPE.
5. SR Adoro by Ivoclar Vivadent.
Polymers of IInd Generation IRC

For an advanced rate of conversion, additional light curing extra orally is not enough. Specific conditions are essential for the polymerization of IInd generation IRC. It consists of pressure, vacuum, heat and oxygen free surroundings. The different strategies that are used for extra curing are depicted below [1].

**Heat Polymerization:** Eldiwani et al in 1993 proved that the temperature that is applied in the heat polymerization of indirect composites should be higher than the glass transition temperature (Tg) [8]. The perfect temperature for IRC is 120-140°C. Vijanan et al in 2007 confirmed that transition temperature facilitates in a wide spread mobility of polymer chain, favoring extra cross linking and pressure relief [9]. Composites should no longer get overheated. Overheating results in degradation of composites [10]. Bagis et al observed that post curing reduces the amount of monomer which is unreacted. Biocompatibility can be increased by post curing [11]. The thermal energy is increased by the combination of heat and light. The conversion of double bonds is increased due to this mechanism. Dual curing results in the increase of wear resistance by 35%.

**Nitrogen Atmosphere:** The polymerization is repressed because of the presence of oxygen in the surrounding. The restoration turns out to be highly translucent, when all the collected air is expelled. Removing the air voids in the restoration provides an appearance of defect-free finish of the enamel. The restoration walls get weakened due to the presence of the entrapped oxygen and it additionally enhances the wear rate. The pressure of Nitrogen impacts the abrasion properties, esthetics, wear of the restoration and rate of conversion. This is proved by Leinfelder et al in 2005. Prior to the curing of the material, the nitrogen pressure removes the internal oxygen. This strategy of curing is utilized in BelleGlass and Sculpture Plus [12].

**Soft Start or Slow Curing:** This idea is first portrayed by Mehl in 1997. The idea expressed the slow rate of curing and it will permit a more prominent rate of conversion [13]. Premature polymerization occurs due to rapid polymerization. This avoids the further proliferation of the molecule. Both BelleGlass and Cristoball utilize this strategy for preparing composite.

**Electron beam irradiation:** This is another strategy for enhancing the properties of composites. This concept is put forwarded by Behr M et al in 2005 [14]. At the point when a polymer is introduced to the electron irradiation, two major reactions happen. The reactions are chain linkage and chain breakage. Initiation of dense packing happens during the rupture of chain. The bond between the matrix and filler is impacted by this process, thereby enhancing the mechanical properties. This builds the achievement rates of polymerization. The two major drawbacks of this technique are degradation of the polymer and staining of the resin. The radiation measurement that is typically utilized in this technique is 200 KGy. This idea is introduced by Vaishnavi et al in 2010 [15].

**Fiber Reinforcement:** Smith in 1960 presented the fiber-reinforced composites. Indications of fiber reinforced composites are: (a) when there is vast restoration, (b) when there is minimum enamel for adequate bonding. In this strategy, fibers of composites are utilized as a base and indirect composite is included. To increase the bond of the overlying composite during production, the fibers are surface treated. Graphite/carbon fibers, glass fibers, and polyethylene fibers were used. The generally utilized fibers are polyethylene and glass [16, 17, 18, 19]. At the point when the forces applied are parallel to the fiber introduction, it causes major failure to matrix and in this way, it provides very less support. A compound with high flexural quality, high modulus of elasticity, high increased fatigue & impact resistance and low deformation is the basic criteria in high stress loading zones. The flexural quality and modulus of composite relies on the fiber position, aging, volume and
design. The unidirectional fibers upgrade the flexural quality. The utilization of unidirectional glass fibers, which are aged or not impregnated upgrade the flexural quality. At the point when the polyethylene fibers are included on the side of compaction, it enhances the hardness of the material. This study is conducted by Dyer et al in 2004 [20]. Ellawaka et al and Bae et al listed the alternative vital elements which impacts the modulus of fiber reinforced composites [21, 22]. They are as follows:

- Physical properties.
- Chemical properties.
- Interfacial bounding.
- Comparison of modulus between the fiber and the composite resins.

**Properties of II-Generation IRCS**

**Mechanical Properties:** Enhanced mechanical properties are reported in materials which have higher filler content [23]. In 2002, Neves et al proved that the filler content is directly proportional to the hardness of these composite materials [24]. Leinfelder KF in 1997 studied the newer developments in resin restorative systems. The increase in wear resistance of IRC is due to the prevention of cross linking by monomers. It helps in the improvement of physical as well as mechanical properties [25]. Thus, IRC can be considered as excellent substitutes for natural teeth.

**Optical Properties:** Direct resin composites show reduced color stability. The important factors which affect the color stability of composites are the curing mechanism and the unreacted double bonds. Nakazawa in 2009 stated that this may be due to the number of remaining double bonds which is not involved during the conversion. When IRC named Sinfony was polymerized with light of high energy source, it results in the increase of mechanical properties. But it shows yellow discoloration. It may be due to the disintegration of the composite due to high exposure to heat [26]. Papadopoulos et al in 2010 stated that clinically satisfactory changes were found in IRCs on curing and after aging process [27].

**Marginal Adaptation and Micro-leakage:** The amount of micro-leakage is relatively less in inlays which are heat treated. Aggarwal et al. in evaluated the marginal adaptation and micro tensile bond strength of direct vs indirect Class II composite restorations in an in-vitro model and found that IRC showed better marginal adaptation and bond strength [28].

**Surface Properties:** The surface roughness and composition of a resin composite has influenced the biofilm adherence. Accumulation of plaque results in the progression of secondary caries. It causes the failure of IRC. If the surface of the material is rough, it causes the accumulation of plaque. Smooth surface finish and less biofilm adhesion is seen in small filler size. Polishing with diamond pastes gives a smooth surface. Presence of remaining uncured monomers also enhances bacterial adhesion [29].

**Surface Treatments of IRCs:** Air abrasion causes strongest repairs. It resulted in increased shear bond strength. It is directly related to the bonding between the tooth and the restoration. Hydrofluoric acid is used for surface treatment. Alteration to the microstructure of resin composite occurs due to this acid. It is due to the dissolution of the inorganic particles [30].

**Color Stability:** Arocha et al conducted a study to determine the color stainability of indirect CAD/CAM processed composites. Spectrophotometric analysis was done for determining the color stainability. CAD/CAM processed composites were kept in staining solutions for determining the color stainability. It exhibits more stainability than the laboratory-processed composites. The color stainability of composites is directly related to water absorption capacity. It is based on the hydrophilic/hydrophobic nature of the resin matrix. This is also influenced by the chemical composition of beverages which is commonly done for the experimental studies [31].

**Next Generation Materials**

The survival of IRC restorations cannot be assessed in the absence of long-term studies. The introduction of newer generation materials will rectify most of the clinical failures like polymerization shrinkage, improper contacts
1. Classification Based on Type of Fillers

**Micro-Filled Composites:** Micro-filled composites are agglomerates of inorganic colloidal silica particles embedded in resin filler particles. The size of microfilled composites ranges from 0.01-0.1 µm. The particle size is less in micro-filled composites. The addition of filler particles into the matrix greatly improves the properties of the material. Microfilled composite resins are the primary choice for anterior teeth where superior esthetics is needed. The microfilled composites were introduced in 1980. Due to the presence of small filler particles, microfilled composites were translucent and can be easily polished. This made the microfilled composite, the first highly esthetic composite resin material [32].

**Fine Hybrid Composites:** Fine hybrid composites are developed to achieve better surface smoothness. It is used in high stress bearing areas which require improved polishability. The particle sizes ranging from 0.6-1 mm and containing 0.04 micrometer sized colloidal silica. It is available in different color ranges. It mimics the tooth structure and shows reduced curing shrinkage. It shows low water absorption and excellent polishing and texturing properties. It can be used for both anterior and posterior teeth.

**Coarse Hybrid Composites:** The increased size of filler content makes it useful in high stress bearing areas. It can withstand high masticatory forces. The particle size ranges from 0.6-1 µm. The properties of the materials can be improved by the addition of the filler particles. The strength is increased in this type of composites. The increased particle size causes reduced bulk fracture. This type of composites can be widely used in the posterior restorations and class IV restorations, where high fracture resistance is needed. It can be used in incisal edges and small non-contact occlusal cavities [33].

2. Classification Based on Fabrication Method:

**Direct-indirect Method/Semi-indirect Method of Fabrication:** Direct step - After applying the separating media into the oral cavity, the composite material is compacted into the oral cavity. Initial curing is done after the procedure. The removal of inlay is quite easy because of the application of the separating medium. Indirect step - The restoration is then subjected to heat processing at 110 degrees for 7 min. In this strategy, impression is not required. The technique can be completed in single sitting.

Example of the direct-indirect method of IRC:

a. Visi-Gem (3M-ESPE) system: Initially intraoral curing is done, after that restoration is cured extra orally by using light and vacuum for 15 minutes.

b. Concept (Ivoclar) system: Chair-side curing of the restoration is done initially. It is then subjected to heat and pressure extra orally at 121° c for 10 minutes under 85 psi.

c. Dentacolor (Kulzer) system: This system uses heat for extra-oral curing.

d. Clearfill CR inlay (Kuraray) system: This system utilizes both light and heat for curing.

**Indirect Fabrication Method:** An individual die is manufactured for the inlay preparation. The isolating medium is applied to the die. Incremental condensation of composites done. The surface is light cured for 40 secs. The light cured inlay is separated and later it is cured by heat in an oven for 15 min at 100° C. Benefits of this technique: (a) proximal contours can be made accurately. (b) The polymerization shrinkage is reduced due to dual curing mechanisms.

**CAD/CAM**

Computer-Aided Design/Computer-Aided Manufacturing is expressed as CAD/CAM. CAD/CAM was first popularized to dentistry in the mid-eighties. Its fabrication is accessible to both chair side manufacturing and chair side-laboratory integrated methods [34]. The latest development in dental materials and Information technology brought about the advances of CAD/CAM era. On this method, 3-D models are constructed, on the ground of digital prototypes. This is completed with the aid of a computer numerical control (CNC) device. Computers are used to create exact projects which could be assessed through various prospective defined as Computer Aided Design (CAD). To materialize virtual objects using CAD, a computer aided
manufacturing (CAM) procedure has been advanced. CAM operates with the assist of a machine plugged to a computer to covert a digital file into a real object. CAD/CAM era employs a non-invasive 3-D imaging gadget. CAD/CAM in dental field allows permitting the manufacturing of custom, patient precise fillings and prosthetics without imposing the regular laboratory strategies. Primarily based on the procedure preferred CAD/CAM ceramic blocks required for the manufacture of restoration consist of leucite reinforced ceramics, zirconia, Li disilicate and composite resin. To determine the kind of ceramics to function, the clinician ought to bear in mind the durability; esthetics and the easiness of customized the milled restorations.

**Advantages and Disadvantages of CAD/CAM Technology**

**Advantages**

1. Applications of new materials–High strength ceramics have been difficult to process using conventional dental laboratory technologies. Therefore, this challenged to apply CAD/CAM processing. Due to successful use of all-ceramic crowns, all ceramic systems have become a viable treatment option.

2. Time effectiveness.

3. Reduced labor.

4. Quality control.

5. The chance of bacterial invasion is less. The need for extra manipulation of tooth is also reduced.

6. It is not always possible for the dentist to create a full arch of precisely parallel preparations. The computer can calculate, design, and build the copings, which can be cemented to yield a well-seating bridge.

7. Scanning an image and viewing it on a computer screen allows the dentist to review the preparation and impression, and make immediate adjustments to the preparation and/or retake the impression if necessary, prior sending to the milling unit or a laboratory. This ensures no calls from a laboratory that the impression is defective. The enhanced representation of the preparation results in better-quality preparations.

8. The patient’s discomfort is tremendously reduced by avoiding impression materials and trays.

9. By using zirconium as implant abutment, light transmission into the gingival sulcus is allowed, thus preventing the grey of opaque metal parts from showing through peri-implant tissue.

10. The latest technique in CAD/CAM shows the occlusion in dynamic state.

**Disadvantages**

1. The main concern in CAD/CAM is the prolonged learning time which causes reduction in treatment time for patients.

2. The other main concern regarding these systems is the lack of clinician’s confidence.

3. The expenses of these systems are very high.

4. Matching the patient’s shade of the tooth to the material blocks remains a challenge to the dentist initially.

5. Some of the CAD/CAM systems rely on margin capture for digitization. The subgingival margin capture is difficult.

6. CAD/CAM is an advancing technology in dentistry. Proper budgeting and software up gradation are mandatory.

**Conclusion**

Indirect resin composite system provides excellent tooth-colored posterior restoration. Numerous IRCs are available nowadays. Post-polymerization cycle, which is the combination of light, heat and pressure, provides excellent physical and mechanical properties to the indirect composite restorations. IRCs perform well in both in vivo and invitro studies. Ceramics can be replaced by indirect composites in different situations. The success of the restoration depends on the proper diagnosis, planning and excellent laboratory support. More studies are needed to determine the survival rates of indirect resin composite restorations. The indirect composite restoration could be an excellent choice for the patients when indicated. Since there is no ideal "one-fits-
all restorative system” that could be successfully applied to every clinical condition, it is the doctor’s responsibility to select the appropriate restorative materials and techniques for each patient after a thorough examination and diagnosis.

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