Indirect Esthetic restorations

Introduction

In spite of the fact that simplicity of restorative dentistry dictates direct approach including cavity preparation and immediate restoration of any tooth defect. Yet, in some cases indirect restoration may be the only successful resort for restoration of anatomical and functional relation of the offending tooth.

The search for the ideal restorative material continues. Though the fact that amalgam alloy still remain the most widely used restorative for posterior teeth, but there has been increased demands for esthetic restoration and also growing concern about biocompatibility, strength of existing restorations.

General indications for indirect restorations:

1. Extensively damaged teeth: where the direct restorations cannot solve solely the problems of restoring proper contour, contact and occlusion.
2. Uncooperative patient: wise management of such patients requires minimizing chair side time by taking an accurate impression and completing most of the restorative steps outside the patient’s mouth.
3. Deeply seated subgingival cavities, where proper finishing and polishing of direct restorations is difficult if not impossible.
4. Solving of occlusal problems such as severe attrition with decreased vertical dimension and collapsed lower third of the face may cause dramatic deterioration in the interarch relation and tempronmandibular joint troubles.
5. Correction of esthetic derangement, such as excessive discoloration caused by fluorosis, peg lateral incisors, and tetracycline stains when it is difficult to be removed by other esthetic alternatives.
7. Solving some problems of direct restorations.
Classification of indirect restorations:

1) According to material:
   a. Metallic: e.g. gold –silver palladium-non precious.
   b. Non-metallic: i.e, esthetic.

2) According to technique:
   a. Direct technique, some of the steps are done in the patient’s mouth.
   b. Indirect technique requires impression taking and detailed laboratory steps.
   c. Indirect-direct technique, initial fabrication is done on a model.

Indications of indirect resin restorations:

1. Regular attendees requesting tooth colored restorations.
2. Good standard of oral hygiene.
3. Cavities free from marked undercuts.
4. Sufficient tooth structure available for bonding.
5. Occlusal load must not exceed the flexural strength of the restoration/tooth complex.
6. The offending tooth must not show evidence of excessive wear.
7. Ideally, the cavity margins must be placed in enamel.

Contraindications of esthetic inlays:

1. Poor oral hygiene.
2. Excessive tooth wear.
3. Impossible moisture isolation.
4. Insufficient tooth structure available for bonding.

Cavity preparation for esthetic inlays:

The concept of cavity preparation for indirect esthetic restorations is completely different than inlay preparation for cast gold restorations. The following differences must be taken into consideration during preparing a cavity for esthetic inlay restoration:

1. The final preparation does not need extension further than initial defect.
2. Removal of cavity undercuts only.
3. The retention form depends mainly on the micromechanical bonding of the bonding system and the composite resin cement.
4. A butt-joint cavo-surface margins
5. Sharp internal line angles must be avoided
Cavities lining for indirect esthetic restorations:
The reason for cavity lining of esthetic inlay preparations is not the same for amalgam and gold preparations.

The objectives for lining are:
1. Removal of all cavity’s undercuts. It is not necessary to cut away all undercuts providing that they can be removed by blocking them by suitable liner.
2. The liner should provide pulp protection.
3. For non-vital teeth, the liner or core should be adequately retained.
4. The lining material adjacent to outer tooth walls should not block light transmission.
5. It must be compatible with the resin material and the luting cement.

The best lining materials are:
1. Resin modified glass ionomer.
2. Visible light cured composite resin.

Indirect composite resin restorations
Composite resin inlays were developed to overcome some of the problems encountered by clinicians during fabrication of direct composite resin in posterior teeth. Moreover, they solved most of the clinical problems of direct composite resin restorations including marginal leakage, increased wear, and improper restoration of contact relations of the inaccessible areas.

Techniques for fabrication of composite resin inlays:
The fabrication techniques for the composite resin inlays depend on the specific system of materials being used. Three different fabrication techniques are available namely the combined direct/indirect (semi-direct) technique, the indirect technique on stone die, and the indirect flexible model technique.

1) Direct / indirect (Semi-direct) technique
The rationale of the semi direct approach is to provide the patient with the benefits of luted restorations without the cost of indirect lab-made inlays or onlays.

* Steps for fabrication:
1) Lubrication of the Inlay Preparation:
Once the inlay preparation has been completed, the tooth and cavity preparation are liberally painted with a lubricant on a disposable brush. This lubricant must be
compatible with the composite resin inlay restorative material and will allow inlay removal after intraoral light curing.

2) **Matrix and Wedge Placement:**
A retrainerless contoured, clear matrix is placed and clear reflecting wedges are placed at the interproximal gingival margins. The wedges are firmly placed to create rapid separation of the teeth, compensating for thickness of the Mylar matrix band and allowing for the interproximal contact between the inlay and adjacent teeth.

3) **Composite Resin Inlay material Placement:**
The composite resin inlay material is placed into the inlay preparation by taking the high-viscosity resin paste, placing it into the proximal box, and gently condensing it with a ball burnisher. After the composite resin has been placed in the proximal box, the occlusal portion of the preparation is completely filled and gently condensed with a ball burnisher that has been lightly coated with a resin adhesive to prevent the composite resin from sticking to the end of the burnisher.
The end of the light-curing tip is placed firmly on the end of the reflecting wedge and the interproximal area is cured for 60 seconds. The interproximal surfaces are cured from the facial and lingual aspects; then the occlusal surface is cured for 60 seconds also.

4) **Inlay Removal:**
After the completion of light curing, the inlay must be removed from the preparation. A scaler is gently placed on an interproximal surface, taking care to avoid any margins.

5) **Oven Tempering:**
Separator lubricant is painted on all the inlay surfaces. This will act to exclude air and will allow the inlay to completely cure without an air-inhibited layer. The air-inhibited layer is the soft test layer of composite resin and should be excluded whenever possible. The inlay is then light cured for an additional 60 seconds. The composite resin inlay must now be tempered in a special tempering oven.

II) **Indirect Technique**
The alternative method of composite resin inlay fabrication is to make an impression of the prepared tooth and fabricate the inlay on a die. The indirect inlay technique can be performed as either a one-visit or two-visit method. The one-visit method involves making an impression with a vinyl polysiloxane material and pouring the impression with a fast-setting die stone, which will set within 5 minutes. The following description applies to both one-visit and two-visit
methods. The difference is in the sequence of the fabrication and whether it takes place in the office or the laboratory.

*Steps for fabrication:*

1) **Impression Making:** The impression should be made with either a polyether or a vinyl polysiloxane impression material. Either of these materials can be poured in stone immediately and also will remain stable if the impression is sent to a dental laboratory. The impression is then poured up in a die stone for inlay fabrication. For the in-office technique, a fast-setting stone should be used.

2) **Provisionalization:** The aim of temporarization is to:
   a. Protect the pulpo-dentinal complex from any bacterial, mechanical, and thermal aggression.
   b. Stabilize relations with proximal and antagonist teeth, as well as maintain an acceptable function. However, these temporaries have to stay in the mouth for a short period because it is advisable to proceed with the cementation of definitive restorations as soon as possible, generally within a week of impression taking.

**Technique of Provisionalization:**

a) The provisional restoration can be constructed directly on the prepared tooth in the patient’s mouth.

b) A light coat of the patient’s own saliva may be pained into the preparation to act as a lubricant.

c) Two drops of monomer liquid are placed into a dappen dish and enough powder is added to form a runny mix of acrylic resin. When the mix acquires slightly less flow, a disposable brush is used to paint some of the acrylic resin into the tooth preparation, covering the gingival wall. When the mix becomes doughy, it is placed into the cavity preparation with an angled flat plastic instrument.

d) The patient should close into maximum intercuspation and go through all mandibular excursive movements to establish the parameters of an occlusal form. After polymerization, the acrylic resin restoration is removed from the tooth. The excess acrylic resin is trimmed with acrylic resin burs or abrasive disks.

e) After the finishing stage, the restoration is placed back into the tooth preparation to evaluate the fit and marginal adaptation of the restoration. Articulating paper is used to check the occlusion and make any adjustments that are necessary to maintain the occlusion and proximal contacts. The surface of
the provisional inlay is then glazed with a light cured glazing resin. The restoration is cemented with non-eugenol – based temporary cement.

3) Cast Preparation:
Once the die stone is set, the cast should be mounted and sectioned in preparation for the inlay fabrication. Care should be taken when the cast is sectioned, so that the gingival contacts remain intact; this should be done even at the expense of the adjacent tooth. The impression can be poured a second time if an additional cast is desired to better evaluate the proximal contact area and the path of draw.

4) Inlay Fabrication:
The preparation margins are outlined with a red pencil, a separating medium is applied to the internal surface of the die as well as to the surrounding and opposing teeth. One or two drops are placed into the cavity preparation and spread over the tooth so that each margin is well coated. The separating medium is then dried with a gentle air stream. The composite resin of the correct shade is dispensed onto a pad. The composite resin can be built up in two layers if shading of dentin and enamel is desired. Proximal and occlusal anatomy should be developed at this stage. Light curing should then be completed; each surface is irradiated for 40 seconds. After light curing, the inlay is removed from the die by pressing on the proximal surface in an occlusal direction.

5) Heat Treatment:
The resin inlay is heat treated in an oven for 15 minutes at 100˚C in a heat-curing Oven. This oven can maintain the curing temperature over the curing time for multiple restorations. The unit is very compact and requires little bench-top space.

6) Finishing and polishing:
After heat treatment, the inlay is carved on the die with fine diamonds and mounted abrasive stones. The inlay is then polished with composite polishing paste on a buff wheel.

7) Characterization:
The inlay is thoroughly cleaned ultrasonically in a water bath. It can then be characterized by applying one of the resin-based colorants to the surface of the inlay. This characterizing stain is applied to pits and fissures with a brush. The stain is then light cured for 40 seconds.

III) The Flexible Model Technique
The flexible model technique is an alternative to using the natural tooth as the die for inlay fabrication.

* Steps for fabrication:
1) The technique starts by making a polyvinyl siloxane impression of the preparation. After the impression is made, a silicone-releasing agent is sprayed onto this impression.
2) A heavy-bodied polyvinyl-siloxane is now placed into the impression to make the flexible-working model by injecting a light bodied material into the preparation impression, followed immediately with a putty material.
3) The rubber base material is allowed to set for the manufacturer’s recommended time and the impressions are separated. The use of the silicone releasing agent facilitates separation, if this agent were not used the two silicone impression materials would bond together.
4) The resin inlay is now fabricated as with the semi-direct technique.

**Advantages Flexible Model Technique:**
1. There is lower cost, less inconvenience and fewer traumas for the patient because a separate second appointment is eliminated.
2. The dentist, an in-house laboratory technician, or a capable assistant can make the restoration.
3. Provisional restoration is not needed, reducing time and cost and eliminating contamination of tooth preparation by provisional cement debris.
4. Polymerization shrinkage of resin occurs on the die and not on the tooth.
5. The technique requires minimal clinical time (it is possible to seat the restoration 20 minutes after impression).
6. Ability to achieve improved contours improved esthetic results and minimal finishing times. This extra oral technique also allows the dentist to delegate the fabrication of the inlay to a competent auxiliary.

**The drawbacks of this technique may be summarized as follows:**
The cost of impression materials, the time needed for impression material to set and possible deformation of the original impression when making the flexible die.
1. Tooth preparation should not have thin, weak cusps because the accuracy of the die is compromised as a result of the flexibility of the die silicone.
2. The opposing reference is not available because the restoration is generated on a single base from a single – quadrant impression.

**Advantages of indirect composite resin restorations:**
The relative advantages of indirect resin restorations over the direct technique of application are
1. Controlled polymerization shrinkage, given that small marginal discrepancies of fit may be made good with the luting cement.

2. The physical properties of the composite resin, such as diametral tensile strength, hardness, in-vitro wear and color stability can be improved by post-curing of the material by application of intense light or heat at an optimum temperature.

3. Clinically, the most important advantage of indirect composite resin restorations is the ability to restore the contact, contour and occlusion apart from the restricted inaccessible oral cavity.

**Disadvantages:**

1. Unfortunately no clinical data support the manufacturer claim that post-curing improves the wear characteristics of the material.

2. There is also, another unsolved problem, which is the impaired bonding of composite cement to the fitting surface. Roughening of the inlay fitting surface with diamond burs or sandblasting with SiO₂ powder are suggested means for enhancement of the bond at the composite resin inlay/resin cement interface.

3. The composite resin inlay whether constructed directly or indirectly, requires additional time and skill as compared to direct insertion procedure.

4. These restorations are more expensive for the patient than conventional direct composite resin placement techniques, because of the increased time required as well as the additional instrumentation.

### CERAMIC INLAYS

In 1913, NS Jenkins, highlighted advantages of porcelain inlays and he concluded “to add restoration of the original beauty of the tooth is a supreme triumph”

The word ceramic is derived from the Greek “Keramos” i.e. pertaining to pottery as an art. Porcelain is defined as a fine kind ware-earthen having a translucent body and a transparent glaze. The history of porcelain inlays goes back to more than 100 years ago. Porcelain inlays have been used since this time but did not gain popularity due to:

- Problems attributed to the exacting technique.
- The inherent brittle nature of porcelain.
- Microleakage and cement failure.
- Poor fit and luting difficulties.
These problems have now largely been overcome by the introduction of “shrinkfree” porcelains, which may be etched and bonded to composite resin luting cement, with the chemical bonding being enhanced by silanization of the fitting surface of the inlay.

**Types of ceramic inlays**

**Man-made ceramic inlays:**
1. Ceramic inlays produced on refractory die material.
2. Castable and pressed ceramic inlays.
3. Ceromers inlays.

**Machined restorations:**
1. CAD/CAM (Computer Aided Designed / Computer Aided Manufacturing) restorations.
2. Celay type inlays.
3. Prefabricated size-matching restorations (Sonicsys).

**Man made ceramic inlays**

1. **Ceramic inlays produced on refractory die material** *(Feldspathic technique)*
   The refractory die technique uses a direct build up of porcelain onto an investment model whose coefficient of thermal expansion is similar to that of ceramic material.

   *Steps for construction:*
   
   **a. Generating of the refractory die:**
   The entire master cast is covered with a clear mold that contains several large holes in its top surface and is attached to the underlying base. A venyl polysiloxane impression material is poured through one hole in the top of the model. The die of the prepared tooth is removed from the impression. This specific portion of the impression is re-poured in a refractory investment. Ceraming process: which converts the casting to a partially crystalline state through a controlled heat treatment in which nucleation and growth of the crystals occur (mica crystals) which are responsible for strength of the inlay. The ceraming process takes about 6 hours.

   **b. Porcelain buildup:**
   The margins of the preparation are marked with a special refractory marker. At least three firings are necessary before final glaze is applied.
2. Castable and pressed ceramics:
They are fabricated by the lost wax technique. Theoretically, the lost wax technique improved fit compared with refractory die technique.

A. Castable ceramic inlay fabrication:
   1. Following tooth preparation and impression making, accurately indexed working cast with individual dies is developed.
   2. Wax pattern is formed to reproduce the desired tooth anatomy and relations.
   3. The wax pattern is invested using phosphate-bonded investment, which is a specific type for this technique.
   4. Wax elimination: once the investment has set, the casting ring is placed in burnout furnace and held at a temperature of 350°C for 30 to 45 minutes. Then the temperature is increased to 900°C, the casting temperature of castable ceramics.
   5. Centrifugal casting technique for ceramic material into the mould to produce an accurate casting is done.

Advantages of castable ceramics:
   1. Increased fit more than conventional ceramic inlays.
   2. Less predicted wear than conventional porcelain.
   3. The thermal coefficient of expansion is close to that of enamel.
   4. Higher flexural strength is reportedly greater than it for conventional porcelain.

Disadvantages:
   1. Lack of surface staining hence any grinding of the restoration leaves an unaesthetic opaque white area.
   2. The whole procedure is a technique – sensitive.

B. Pressed ceramics:
It is considered as a development of the castable ceramic in which glass ceramic into the mould by a pneumatic pressure system. However surface staining is recommended for both systems. Each stain firing lasts for at least two minutes.

Advantages of pressed ceramic system:
   1. Relatively simple and accurate procedure.
   2. The pre-cerammed porcelain has a high degree of flexural strength.
   3. It can be used in restoration with very thin sections (about one millimeter).
   4. The lost wax technique and ceramic injection allow for accurate fit.
Machined ceramic restorations

I. CAD/CAM (Computer Aided Design- computer Aided Manufacturing):

Restorations that are constructed from solid blocks of porcelain milled into the correct shape and dimensions utilizing a computerized machine. The CEREC (ceramic reconstruction) machine was the first introduced system and it comprises a miniature camera, computerized designer and milling machine with a self-contained water supply.

Technique:

1. Optical impression:
The miniature intra-oral camera maps the cavity contours after coating the tooth with a thin layer of titanium oxide to eliminate light reflection. It is essential to position the camera over the long axis so that the computer can read all internal walls and cavosurface equally.

2. Computer generated restoration design:
The restoration is designed from the image shown on the computer screen by using a series of icons or symbols. Once the restoration has been designed, the computer develops a three-dimensional image of the inlay, onlay, or veneer.

3. Milling procedure:
The milling is accomplished by a three- axis of rotation cutting machine which mills the restoration from prefabricated ceramic blocks with different shades, which generally takes 4 to 7 minutes to complete the procedure.

4. Final occlusal adjustments are done in the patient’s mouth.

Advantages of the Cerec system:

1. Single appointment.
2. No impression
3. Wear hardness is similar to enamel.
4. Excellent polishing characteristics.
5. Less fracture because it is milled from homogeneous blocks.
6. The whole procedure is accomplished in 1- 1 ½ hours

II. Celay system

The manufacturer of Celay machine tried to overcome the difficult technology of Cerec system and designed a simplified high precision milling machine.
Technique:
1. **Proinlay:** A removable, dark blue composite inlay is made directly in the patient’s mouth or indirectly on an accurate model.
2. **Tracing:** The blue inlay is manually traced with a stylus. A thin coating of white is used to control the tracing. Contact of the stylus with the boundaries of the Proinlay will remove the white powder and the blue color becomes visible.
3. **Milling:** The stylus has a fixed relation to a turbine, which mills the inlay out of a ceramic block using diamond points to produce a finely worked surfaces especially the occlusal anatomy.

**Advantages of Celay system:**
1. A precisely fit ceramic restoration can be done in one visit.
2. No need for laboratory technician.
3. The processing time is very short, complete inlay in 12-13 minutes.

III. Prefabricated size matching ceramic inlays (*Sonicsys*)
It is a recently introduced ceramic inlay system to provide easier and less costly prefabricated ceramic restorations for proximal cavities of posterior teeth.

**The system is composed of:**
1. Varying sizes of ultrasonic abrasives with the abrasive particles are bounded to all surfaces except the surface facing the adjacent tooth to avoid injury during cavity drilling.
2. Standardized ceramic restorations to match the corresponding abrasive tips. They are cemented to tooth as other ceramic and composite inlays. If occlusal caries does exist, a conservative cavity and direct ceromer or composite resin material could be used for occlusal restoration.

**Restoration placement for composite and ceramic inlays:**
1. **Isolation:** preferably by the application of rubber dam.
2. **Cleaning** and drying of the cavity: to remove any traces of temporary restoration.
3. **Priming:** for ceramic inlays only, apply silane-coupling agent to the fitting surface after etching with hydrofluoric acid.
4. **Matricing:** It is advisable to apply matrix to prevent gingival flow of excess cement.
5. **Etching,** washing, drying, and application of the bonding system according to manufacturer’s instructions.
6. **Cementation:** Apply either chemically activated or dual activated composite resin cement to the fitting surface of the inlay and the prepared cavity.

7. **Seating** of the inlay: Gentle seating of the inlay is done by finger pressure followed by steady pressure from the opposing teeth.

8. The excess luting cement is then removed with a sponge pellet.

9. **Curing:** Visible light curing to initiate the polymerization reaction of the dual cured resin cement.

10. **Removal** of rubber dam.

11. **Finishing & polishing:** The margins are finished using flexible discs or diamond burs, Polishing is done by composite polishing discs, white rubber cups or porcelain polishing kits.