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Review Article

Indirect Restoration

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Abstract

Restorations in dentistry are done to repair parts of teeth lost as result of either caries or trauma. An indirect restoration is a restoration that is not done directly into the mouth but prepared outside. The clinician takes the impression of the tooth preparation and sends it to the lab for fabrication. There are four types of indirect restoration i.e., Inlays, Onlays, Crowns and Veneer/Laminates. This paper describes composite inlay method of indirect restoration. The findings revealed most obvious advantage of the indirect technique relates to its higher potential for generating the appropriate anatomic form, as well as proximal contact and contour. In cases where superior contacts, contours and esthetics are much needed, indirect restorations have shown several advantages, especially when ceramic materials are used. Indirect restorations have shown to have a greater shelf and a better success rate and are therefore much more popular.

Keywords: Indirect Restoration; Inlays; Onlays; Crown

Introduction

Missing or damaged teeth are generally repaired by providing a restoration. Restoration provides a proper tooth function and form to the missing tooth structure while providing for the esthetics as well [1].

Restorations on the basis of method of fabrication are classified as either direct restorations or indirect restorations.

Direct restorations are fillings done directly onto the tooth, while indirect restorations are prepared outside the mouth and then cemented to either the tooth or the supporting tooth structure in a separate procedure [2].

Extracoronal restorations cover the crown completely or partially. The retention and resistance form is provided by the external walls of the tooth and the overall surface area. Examples are partial/complete veneers crown, laminates.

Intracoronal restorations are the restorations which are confined to the coronal aspect of the tooth gaining the resistance and retention form from the intimate fit of restoration to the opposing walls. Examples are inlays and onlays.

Inlays and Onlays are generally practiced when a molar or premolar is too damaged to support a basic filling, but not so severely that they require a crown [3].

Dentists are often confused in various clinical scenarios as to which avenue they should pursue - whether direct or indirect restorations. Therefore, posterior teeth having large cavities showing failed direct restorations with multiple missing cusps; anterior

teeth having large interproximal cavities including one or both mesial and distal incisal edges requiring replacement , are preferred examples for indirect restorations [4].

In recent years, several new dental materials have been developed making the choice and the technique of restoration of which is relatively simple. The choice of material is usually depended upon the size of lesion, patients compliance, and esthetics [5].

Upto the date gold is referred to as the standard material to be used in indirect restorations because of its excellent biocompatibility [6] but due to high cost and technique sensitivity new material was introduced porcelain fused to metal (PFM) which also provided with strength but adaptation of base metal underlying the porcelain became the major issue of concern for dentist [7].

Although the advent of all ceramic system has revolutionized the indirect restoration protocol, initially Empress (pressed ceramics) was used which had excellent surface texture and strength [8] but later zirconia replaced the metal part of PFM [9] and latest CAD/CAM technology has given promising result with decreased cost.

The need of this paper is to understand the technique of indirect restoration, the possible conditions where we can use this technique to remove the confusion among practitioners and to understand the materials used which gives us the precision result with decreased cost.

History of indirect restoration

Indirect materials are generally prepared in a dental laboratory and then placed in or on the teeth; requiring two or more visits to complete the restoration. In the history of operative dentistry, the earliest material used to make dental impressions was beeswax [10], followed by use of gutta - percha. Later, Plaster of Paris came into use in dental profession after it had been discovered from Paris [11]. John Greenwood was the first to use plaster of Paris as an impression material but was not able to produce appropriate impression because its inflexibility that caused fracture upon its removal [12].

Charles Stent in 1857 developed the modeling compound to improve the drawbacks of gutta-percha and provided with the much needed plasticity, stability, strength, and red coloration [13-16] in 1925, Alphons Poller introduced reversible hydrocolloid to dentistry to fabricate plaster reproductions [17]. Later, Sears used agar-type reversible hydrocolloids for taking impression in fixed partial denture [18]. Japan provided for the major source of agar, so during world War II, the irreversible hydrocolloids (alginates) were invented to dental profession [19]. In 1953, polysulfide impression materials were introduced to operative and prosthodontic dentistry [20]. Then, the discoveries of polyethers, condensation silicone, and addition silicone offered more stable and less messy materials to dentistry.

The evidence for the use of cast restoration was first found in Mesopotamia (3000BC) where copper was being used to cast. The technique of casting was first introduced in Egypt (2500BC) where lost wax molding process was developed for gold casting. Estrucans (500BC) produced bridges made of soldered gold bands. Then, this technique was adapted by Romans and Europe until the 18th century. Lateron, Chinese developed specific bronze alloys and made elaborated use of lost wax process to produce castings. Gold inlays are the oldest castings found in teeth of natives of Equador and Pre- Columbian Indians [21].

However, there is evidence that the Aztechs and Maya made gold castings in mold prepared from clay or Plaster of Paris. After the introduction of dental cement oxychloride of zinc in 1860, various materials were used for construction of dental inlay, for example, grounded porcelain and gold foil [22]. In 1897, Dr. D. Philbrook described a method of casting for restoration of posterior teeth. In 1907, William H. Taggart introduced lost wax technique for gold castings. Van Horn introduced various compensation techniques for alloy shrinkage whereas Weinstein added boric acid and Moore added chlorides to investment to minimize shrinkage and enhanced thermal expansion respectively.

In 1937, Pincus developed thin facings made of air-fired porcelain. He attached these thin labial porcelain veneers temporarily with denture adhesive powder to enhance the appearance of the Hollywood actors for their close-up photographs. Pincus was aware of the importance of the “Hollywood smile” as an integral part of the image and public opinion and provided a viable option to the full crown for the actors who needed to temporarily change their smile, yet they possessed very little strength, and the technology necessary to provide a permanent means of attaching the veneers to tooth structure was lacking. This reversible technique provided an alternate for those who wanted their smiles to improve without the need of more aggressive crown preparations. The gingival veneers were introduced in 1955 by Emslin and to mask the unes-

thetic appearance of gingival recession in a patient who underwent a gingivectomy. In 1990, Dr. Mat Carty introduced lumineers followed by Barnes Ian E who introduced porcelain laminate veneers for dentist and technicians in1999. The MAC (Micro Advanced Cosmetic division) veneer was introduced in 2005, by Micro Dental laboratory at Dublin, Dr. Joel. D. Gould in 2008 introduced The Vinci Veneers at the Da Vinci laboratory in California [23].

Nowadays CAD/CAM system is being used for making indirect restorations providing high strength and accuracy. The First chairside ceramic inlay was made in 1985 using CAD/CAM device which was two dimensional, but Cerec 3 was introduced in 2000 with three-dimensional graphics.

Types of indirect restorations

- Inlays
- Onlays
- Crowns
- Veneer/laminates

Inlays

Definition

A composite inlay is defined as a restoration which is cemented into a dental cavity as a solid mass that has been fabricated from composite resin with a form established either by an indirect or a direct procedure outside the oral cavity.

Indications

- Esthetic - for class I and class II restorations located in areas of esthetic importance.
- Patient's demand requiring tooth colored restorations located in areas of esthetic importance.
- Patients with good oral hygiene.
- Moderate to large size lesions, where sufficient tooth tissue appropriate for bonding and free of undercuts remains following cavity preparation.
- Restoration where the isthmus is less than one third the cuspal distance.
- Replacement direct posterior restorations that have been successful for a long time but now need replacement because of fracture, wear or recurrent caries.
- For restoring lesions of class I or II defects or replacing large existing compromised restorations, which are wide faciolingually and do require cusp coverage.
- When better control over contacts and contours is desired as compared to direct composite restorations.
- Restoration that will not be overloaded occlusally.
- When sufficient tooth structure available for bonding.
- Ideally, where all cavity margins are in enamel. In an in-vivo study by Ferrari [24] evaluation of the microleakage of indirect composite resin inlays was done. The results shown microleakage was greater when interproximal cervical margins were in dentin than when they were above the cementoenamel junction. When margins remain in enamel, the microleakage was minimal.

Contraindications

- Areas of heavy occlusal forces - As restorations may fracture when they lack sufficient bulk or are subject to excessive occlusal stress, as in patients with bruxing and clenching habits.
- Inability to maintain a dry field as adhesive dentistry require near perfect moisture control.
- Patients who do not maintain oral hygiene.
- Badly broken-down teeth where inadequate tooth tissue remains to create adequate resistance and retention forms for the purpose of bonding.
- Deep subgingival preparations - although it is not an absolute contraindication. Such margins are difficult to record or finish, and hence should be avoided.

Advantages

- Improved physical properties over direct composite restorations, like compressive strength, diameter tensile strength, flexural strength, fracture properties and surface hardness.
- Reduced polymerization shrinkage therefore fewer voids, less microleakage and less post-operative sensitivity than directly placed composites. Most of the polymerization shrinkage occurs prior to cementation so that the only shrinkage that occurs is limited to the luting cement.
- Strengthening of the remaining tooth structure.
- Reduced cuspal flexure.
- Provides a precise control of the contacts and contours.
- Esthetics achieved.
- Conservative tooth structure removal.
- Relatively easy to repair, Improved control over marginal adaptation.
- Less technique sensitive than directly placed composite restorations.
- Minimal wear of opposing teeth.
- Degree of conversion to nearly 100%.

Disadvantages

- Necessity of temporary restoration.
- Technique sensitive laboratory procedures.
- Time consuming and more expensive.
- Bonding difficulties.
- Occlusal and approximal wear. Composite resins have the potential for abrading the opposite cusps when sufficient stresses are involved.
- Short clinical track record.

Tooth preparation

The advent of etched enamel, resin-bonded restorations have changed the general concepts of tooth preparation advocated long back by G. V. Black. The newer preparation designs need no longer adhere to the principles of 'extension for prevention'. In such restorations, tooth reduction becomes considerably more conservative, as the bonding procedures and resultant adhesion to enamel provide ongoing 'prevention without the need for extension', as well as retention in even the shallowest of the preparations.

Preparation design for composite inlays

Clinical principles of tooth preparation

Preparations for indirect resin inlays basically are meant to provide adequate thickness for the restorative material and at the same time a passive insertion pattern with rounded internal angles and well defined margins. All margins should have a 90-degree butt-joint cavo surface angle to ensure marginal strength of the restoration. All line and point angles, internal and external, should be rounded to avoid stress concentration in the restoration and tooth, thereby reducing the potential for fracture.

Removal of old restorations and/or caries

It is preferable to remove any existing restorations and compromised tooth structure and/or caries before deciding on the definitive form of the preparation and final restoration.

Isolation

The teeth involved should be isolated with a rubber dam. A rubber dam is almost mandatory. This makes it easier to visualize the ultimate configuration of the restoration and provides moisture control during placement of any required base.

Important features of preparation design

The pulpal floor should be developed by a combination of calculated, judicious tooth reduction and a fortified glass ionomer cement base, into surface with definite resistance form. The configuration of the pulpal floor can be very according to the depth of the preparation. It need not be classically flat and perpendicular to the long axis of the tooth, as required for cast gold restoration. If cavity is shallow, this will result in weak area in the central fossa of the restoration. In such situations, the pulpal floor should be indented in the central fossa region to parallel the cuspal inclines, resulting thickness of porcelain in the center that is similar to that on the lateral aspects of the restoration. Optimum depth of the cavity should be 1. 5 to 2 mm. The isthmus should be 2mm in width. This decreases possibility of fracture of the restoration.

Axial walls

The axial wall of the cavity preparation should be slightly more divergent from the pulpal floor towards the enamel surface than would prepared for a conventional cast metal inlay. The use of adhesive composite resin luting agents negates the need for parallelism and frictional fit for retention. The increased taper of axial walls.

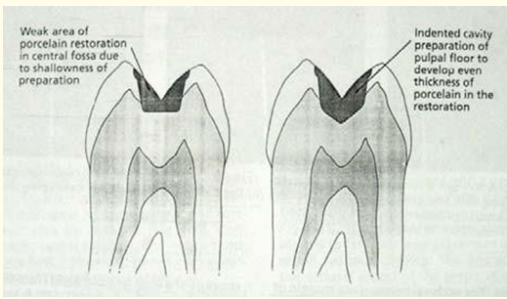

Figure 1: Pulpal floor.

Allow easier placement and removal of the restoration during try-in phase, but taper should not be exaggerated so as to unnecessarily remove additional tooth structure.

Although the optimal gingival occlusal divergence is unknown, it should be greater than 20 to 50 [25]. Burke suggested the taper vary from 4 to 15° [26].

Finish lines

The occlusal cavosurface margin of the restoration should not be beveled. For all walls, a 900 cavosurface margin is desired because tooth-colored inlays are fragile in thin cross-section, which would also have the potential to fracture during seating. There are two schools of thought on the actual configuration of the finish lines. It may be developed as 1) a well-defined, smooth butt joint, or 2) a hollow ground chamfer.

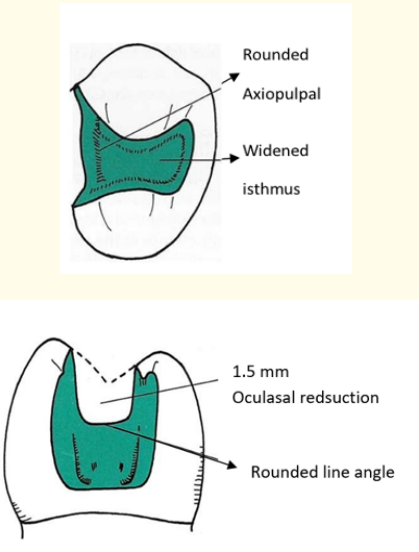

Figure 2: Mesioocclusal (MO) inlay preparation for tooth-colored inlay in maxillary first premolar

(occlusal view). Isthmus should be at least 1. 5 to 2 mm wide to prevent inlay fracture. Axiopulpal line

angle should be rounded to avoid seating errors and to lower stress concentrations.

The hollow - ground chamfer appears to be preferable, because it creates a more effective seal for the restoration and improves the esthetic color blending.

Proximal box

The facial, lingual and gingival margins of the proximal boxes should be extended to clear adjacent tooth by at least 0. 5 mm. These clearances will provide adequate access to the margins for impression material and for finishing and polishing instruments. The gingival margins are extended as minimally as possible because margins in enamel are generally preferred for bonding and because deep gingival margins are difficult to impress and to isolate properly during cementation. Some authors have suggested bevels along the floor of approximal box as long as sufficient enamel remains.

Slot preparation for proximal caries

This procedure incorporates the marginal ridge and proximal surface but not complete occlusal surface; thus, it is an esthetic, conservative alternative to full coverage or compound cast metal restoration.

The round bur is used judiciously remove the undermined marginal area and extend this box form laterally to the extent of the lesion buccally, lingually and pulpally. The box form should be mildly divergent gingiva-occlusally and can be either in the form of dovetail or a flared box, depending on the extent of the caries and outline form of the tooth. It is not necessary for the cavity preparation to extend into the self-cleansing areas, either buccally or lingually and the preparation can, in fact, remain within the confines of the contact area if necessary.

Cusp capping [27]

A cusp needs to be capped if the extension is two thirds or greater than the distance from any primary groove to the cusp tip. If cusp must be capped, a minimal reduction of 1. 5-2 mm is done and with 90^0 cavosurface angle.

- When capping a centric holding cusp, it may be necessary to prepare a shoulder to move facial and lingual cavosurface margin away from any possible contact with the opposing tooth to avoid deterioration of marginal integrity.
- In an *in vitro* investigation, the effect of cuspal coverage was evaluated by comparing the fracture resistance of teeth restored with a composite resin inlay with that of a dimensionally similar onlay. The results indicated that the fracture loads were statistically greater for the teeth restored with onlays than for teeth restored with equivalent inlays.

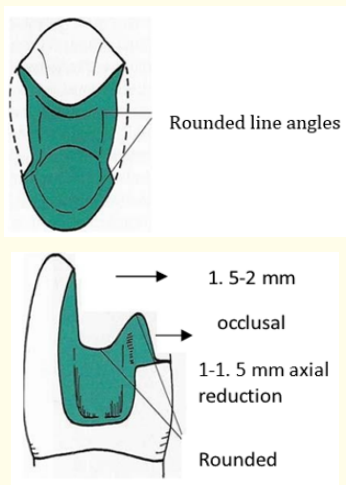

Figure 3: MODL inlay preparation on maxillary first premolar (occlusal view). MODL inlay preparation on maxillary first premolar, proximal view. The lingual cusp has been reduced and the lingual margin extended beyond any possible contact with opposing tooth by preparing a "collar. " Working cusps require 1. 5 to 2 mm of occlusal reduction. All internal and external line angles are rounded.

In an *in vitro* study, it was determined that the composite resins have the potential for abrading the opposing cusps when sufficient stresses are involved. The extent of abrasion appears to be dependent on the size and hardness of the filler particles. Therefore, inclusion of the opposing cusps on the surface of composite resin restorations should be prevented.

Shade selection should be made prior to tooth preparation to obtain a better match. Commonly, an existing restoration is being replaced and it is therefore necessary to match the shade to an adjacent tooth. If a large number of restorations are to be done in a given quadrant, the shade can be selected similar to the shade selection for anterior bonding. As the resin materials are translucent, the restoration will acquire some of the original shading of the tooth. This can be used to advantage for a more natural appearance of the tooth-restoration interface.

After cavity has been cut provisional restoration is placed, if necessary. Placement of provisional restoration is same that of as described in cast gold restoration section. Ceramic inlays and onlay [28].

The decision whether to opt for indirect composite or indirect ceramic is very difficult since both the materials have improved with passage of time and are indicated in large restorations.

Indications

- Small to moderate carious lesions
- Large carious or traumatic lesions
- Endodontically compromised tooth
- Teeth where it is difficult to develop retention form
- When metal allergy is a factor
- Restorations of teeth in an arch opposed by alreadypresent porcelain restorations.

Contraindications

- Patients with parafunctional habits
- Aggressive wear of dentition
- Inablitiy to obtain dry operative field during placement of restoration

Advantages

- Improved physical properties like strength
- Improved wear resistance
- Reduced polymerization shrinkage
- Support of remaining tooth structure
- More precise control of contours and contacts
- Biocompatibilty and good tissue response
- Increased auxiliary support

Disadvantages

- Increased cost and time
- Technique sensitivity
- Brittleness of ceramics
- Wear of opposing dentition and restorations
- Low potential for repair

Tooth preparation

The basic principles of tooth preparation for ceramic restorations are as followed for cast restorations coupled with modifications as required, keeping in view the inherent weakness the inherent weakness of ceramic.

Ceramic is fragile and liable to fracture during insertion and adjustments. To avoid such fractures following features are incorporate (62)

Adequate thickness of ceramic

The strength of ceramic is directly proportional to its thickness which might jeopardise the pulpal health. A uniform thickness of 2mm is considered ideal for ceramic inlays and onlays with a 1. 5 mm axial reduction.

Avoidance of internal stress concentration areas

The internal line angles are rounded and undercuts are filled prior to final impression making procedures since sharp line angles create stress concentration areas.

Maintaining positive path of insertion

This is done by creating a 10” divergence since the ceramic restorations are very fragile and during seating or try in procedures may give way or fracture. Therefore, divergence of 10” will allow proper seating of restoration.

Avoiding bevels of any kind

Cavo surface angles are kept at 90” without any bevels. The bevels reduce porcelain thickness at the edges and weakens the restoration which may subsequently fracture.

Conclusion

As can be concluded from this paper, large rehabilitations in which the dentition has to be restored extensively, indirect restora-

tions allow for preoperative design with wax-up or digital wax-up and better management of occlusion and vertical dimension. The most obvious advantage of the indirect technique relates to its higher potential for generating the appropriate anatomic form, as well as proximal contact and contour. In cases requiring superior form and esthetics, indirect restorations provide several advantages, especially when ceramic materials are used. In cases in where decision making for preparing a direct restoration is inconclusive, indirect restorations prove to be more promising, successful and therefore are used.

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