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"All Aspects Of Indirect Metal Free Restorations - A Review Article"

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Abstract
Over the past two decades, dentistry has witnessed a significant shift towards metal-free restorative materials, driven by the need to improve the aesthetic value of dental restorations. Eliminating metal allows for restorations that more closely mimic the natural dentition, free from traditional materials' dark, opaque substructures. Beyond aesthetics, metal-free restorations offer numerous benefits, including conserving tooth structure, wear compatibility, strength, durability, and improved bonding capabilities. These advancements align with patient preferences for minimally invasive procedures and the preservation of natural tooth structure. Dental restorations are categorized into direct and indirect types. Direct restorations involve placing a malleable material into the tooth that is prepared and allowing it to set, typically in a single visit. Indirect restorations, including inlays, crowns, onlays bridges, and veneers, which are fabricated outside the mouth using dental impressions and are usually bonded in a subsequent visit. Innovations such as the CEREC chairside CAD/CAM system allow for the precise fabrication of ceramic restorations, further enhancing the quality and efficiency of dental restorative procedures. This review explores the evolution, benefits, and clinical considerations of indirect metal-free restorations, highlighting the advancements that have made them a preferred choice in modern dentistry

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I. Introduction

In the last 20 years, dentistry has increasingly adopted metal-free restorative materials to improve the aesthetics of dental work. These options eliminate the dark, opaque substructures found in traditional materials, providing a more natural look. Besides aesthetics, metal-free materials offer benefits such as conserving tooth structure, wear compatibility, strength, durability, and better bonding capabilities, catering to patient preferences for minimally invasive treatments.[1]

The introduction of new materials has expanded available options, emphasizing the importance of factors like mechanical properties, bond durability, and marginal integrity for long-term success. The strength and bonding requirements of these materials depend on the functional stresses they will endure and their location in the mouth, with additional aesthetic considerations for anterior teeth.[2-3]

The ongoing development of restorative materials simplifies the selection process for dentists, ensuring durable and aesthetically pleasing outcomes. An ideal restorative material should closely mimic natural teeth in physical, material, and optical properties, and withstand masticatory forces and wear.[4]

Dental restorations are classified into direct and indirect types. Direct restorations involve placing and setting a malleable material into the tooth in one visit. Indirect restorations, including inlays, crowns, inlays, bridges, and veneers, which are fabricated outside the mouth using dental impressions and bonded in a later visit. The CEREC chairside CAD/CAM system enables precise ceramic restorations, improving the quality and efficiency of dental procedures. This review explores the advancements and advantages of indirect metal-free restorations, highlighting their significance in modern dentistry.[5,6]

II. Indications And Contraindications

The following are examples of the indications for Class I and II indirect tooth-colored restorations, which are based on the restoration's size and aesthetic requirements:

Aesthetics: Indirect tooth-colored restorations are recommended for Class II restorations placed in patient-important aesthetic regions.

Major flaws or prior restorations: When restoring major Class II defects or replacing large compromised pre-existing restorations, especially those that are wide facio lingually and necessitate cusp coverage, indirect tooth-colored restorations should be taken into consideration. The optimum restoration for large preparations is an adhesive restoration that fortifies the remaining tooth structure. Using indirect approaches makes it easier to develop the contours of massive restorations.[7]

When it comes to maintaining occlusal surfaces and occlusal contacts, indirect tooth-colored restorative materials outlast direct composites in larger occlusal posterior restorations. Large posterior restorations involving most or all of the occlusal contacts require the wear resistance that indirect materials give. However, a large indirect ceramic or composite restoration may fracture under occlusal pressure if it lacks sufficient bulk, especially in the molar region.[8]

Economic factors: Regardless of price, some patients want the greatest dental care possible. Indirect tooth-colored restorations may be recommended for these patients for both large and moderately sized restorations that would normally require direct restorative material (often composite).[9]

Contraindications

Excessive occlusal stress or insufficient mass can cause ceramic restorations to crack, as in the case of individuals with clenching or bruxing habits. Severe wear facets or a deficiency of occlusal enamel serve as reliable markers of habits related to biting and grinding.

Inability to maintain a dry field— Despite some evidence claiming that current dental adhesives can combat certain types of contamination. For adhesive procedures to produce excellent long-term clinical results, moisture control must be almost flawless.

Deep subgingival preparations: Preparements with deep subgingival margins should be avoided, albeit this is not a strict contraindication. These margins are challenging to complete and challenging to record with an impression. Furthermore, bonding to the enamel borders is highly recommended, particularly on the gingival margins of the proximal boxes.[8,9]

III. Advantages & Disadvantages

Benefits of Indirect Restorations with Tooth Colour:

1. Greater Physical Qualities: Indirect restorations, made with high-strength materials like composites and ceramics, have better physical properties than direct composites due to ideal fabrication conditions.
2. Range of Materials and Techniques: Composites and ceramics can be created using CAD/CAM or other laboratory techniques.
3. Wear Resistance: Especially for large occlusal regions, ceramic restorations are more wear-resistant than direct composites.
4. Less Polymerization Shrinkage: By reducing polymerization shrinkage and its related stresses, indirect approaches lessen microleakage, postoperative sensitivity, and marginal voids.
5. Strengthening Remaining Tooth Structure: Adhesively bonding indirect restorations can strengthen weakened tooth structures.
6. Accurate Management of Contours and Contacts: Utilising indirect techniques yields more accurate management of forms and occlusal contacts.
7. Good biocompatibility and good Tissue Response: Ceramics have good biocompatibility and are chemically inert.
8. Increased Auxiliary Support: Fabrication can be delegated to dental technicians, optimizing the dentist's time.

Indirect tooth-colored restorations have certain drawbacks.

1. Increased Cost and Time: Compared to direct treatments, indirect techniques typically include two sessions and temporary restorations, which results in higher costs and longer turnaround times.
2. Technique Sensitivity: From start to end, a high level of operator competence is required.
3. Brittleness of Ceramics: If a ceramic restoration is not sufficiently thickened or reinforced, it may break.
4. Wear of Restorations and Opposing Dentition: Ceramics may result in restorations or opposing teeth experiencing excessive wear.
5. Difficulties with Resin-to-Resin Bonding: Because there are less accessible double bonds, bonding laboratory-processed resins to composite cements is difficult.
6. Limited Long-Term Clinical Data: As indirect bonded restorations are relatively new, they have a short clinical track record.
7. Low Repair Potential: If an indirect restoration breaks, it's hard to fix, especially if it's ceramic.

8. Difficult Try-In and Delivery**:** Polishing and delivering ceramics can be challenging due to hard surfaces and potential marginal gaps.[10-12]

IV. Inlays And Onlays

In situations where a molar or premolar is too damaged to sustain a simple filling but not so badly that a crown is required, inlays and onlays are two types of indirect restoration that are utilised. Our clinical experience suggests that Onlays may be used in "extreme" situations, such as a molar that has two or even three missing cusps. Before being bonded or cemented to the tooth, inlays and onlays are prepared outside of the patient's mouth.[12] Onlays and inlays do not completely cover a tooth, unlike crowns, which do. Whereas an onlay covers one or more cusps, an inlay is positioned on the chewing surface in between the teeth's cusps.

In cases where a tooth requires repair or has more than half of its biting surface deteriorated, onlays—also referred to as partial crowns—may be utilized.[13]

The following are the primary indications for creating a ceramic or composite inlay or onlay:
1. In patients who require exceptionally beautiful outcomes.
2. Individuals who practise good dental hygiene.
3. Individuals with allergic reaction to amalgam.
4. In the back teeth where there has been a noticeable loss of firm dental tissue.

When teeth are prepared in a way that provides the necessary support or enough enamel for a successful bonding, it is possible to construct an onlay when there has been a significant loss of tooth tissue. Enamel is significant because it provides a highly predictable and long-lasting adhesive contact.[14-16]

Contraindications
I. Individuals with extreme deterioration.
II. Individuals with inadequate oral hygiene and periodontal disease.
III. Individuals who have tooth erosion.
IV. Individuals whose teeth have lost too much tissue, leaving them unsuitable for bonding.
V. In teeth where there is a lot of discoloured tissue left, which has a bad cosmetic effect.
VI. Individuals have behaviours that are not functional.[16]

Advantages
Ceramic inlays and onlays have the following benefits:
a. High biocompatibility.
b. They don't promote tooth plaque buildup on their surfaces. When paired with cutting-edge bonding methods, ceramic inlays and onlays seem to have exceptional mechanical endurance resistance to wear and don't transfer the forces inside the tooth under functional loads.
c. They fit the tooth properly, and when combined with their superior bonding to the enamel, we see a significant reduction in dentine sensitivity and microleakage.
d. We are able to obtain a high-quality replica of the tooth's anatomy and great contact points because they are built in a lab.
e. Perfect consistency of colour.
f. The bonding between the ceramic and composite cement is adequate. By using silica-based ceramic, we can apply a chemical agent to etch the ceramic, which will increase our connection.
g. Because onlays correctly seal the tooth and stop subsequent deterioration that may typically occur with ordinary fillings, they frequently avoid the need for root canal therapy.
h. Even when margins are placed on, long-term research has shown no correlation with an increase in caries.
i. Over time, they preserve the anatomic form.
j. The thin cement layer reduces the negative effects of polymerization shrinkage. Therefore, it may be that the binding to the dentin is significantly more protected than it would be if direct composite were used.[17,18]

Disadvantages
One of the drawbacks of ceramic onlays or inlays is
1. They are expensive
2. The dentist needs to be knowledgeable about contemporary bonding methods.
3. Difficulties in repairing the ceramic inlay if it breaks in the mouth, but this is achievable with the new composite systems (Adovo-Ivoclar).[18]

To prepare the tooth for an inlay or Onlay, we must have in mind some principles
In order to get the tooth ready for an onlay or inlay, there are a few things to consider.

a. Even out the tooth's internal line angles.
b. Beveled chamfer within the preparation's boundaries is prohibited.
c. A 90-degree angle on the shoulder or a bevelled chamfer is recommended.
d. simple0, smooth preparations having cervical and pulpal walls that are flat.
e. Concave-walled preparations directed towards the masticatory surface.
f. To guarantee optimal adaptation, do not remove healthy tooth tissue for retention.
g. When the dentin is not supporting the cusps, the inlay is changed to an onlay.
h. Even if the dentin supports a cusp that has a crevice in it, onlay preparation is done in these cases.
i. The repair should have a minimum thickness of 1.5 to 2 mm.
j. Use block-out resin to remove undercuts.
k. The tooth's existing buccal or lingual walls should be at least 1 mm thick.

We are prepared to take impressions after the preparations are complete.[19,20]

V. Ceramic Inlay & Onlay

Increased Use of Ceramics:

The use of ceramics as restorative materials has significantly increased over the past two decades due to patient and dentist preferences for esthetic and durable solutions. The capacity to use adhesive cement and acid-etch techniques to fuse metal-free ceramic restorations to tooth structures is a factor responsible for its increased use.

Clinical Significance:

- Posterior Teeth: When posterior teeth are weakened by wide cavity preparations, direct resin-based composites may fail. Ceramic inlays/onlays provide durable, esthetic and biologically compatible restorations in such cases.
- Material Developments: Since 1985, dental ceramics with enhanced mechanical properties have been developed for posterior teeth, allowing metal-free restorations.

Fabrication Techniques:

- Innovative Methods: New processing methods include centrifugal casting (castable glass-ceramic), lost wax technique, pressure injection of ceramic ingots (pressable ceramics), and CAD/CAM systems.
- Popularity: These innovations have increased the popularity of ceramic inlays/onlays due to their esthetic appeal and advancements in materials, fabrication, adhesives, and luting agents.[21]

Ceramic Materials:

- Types: Hot-pressed ceramics, machinable ceramics and Feldspathic porcelain, designed for CAD/CAM systems.
- Properties: Ceramics have mechanical and physical properties similar to enamel than composites, with excellent wear resistance and a coefficient of thermal expansion similar to tooth structure.

Feldspathic Porcelain Inlays and Onlays:

Composition TheMinerals that are partially crystalline (feldspar, silica, and alumina) in a glass matrix make up dental porcelains.

• Fabrication: Using distilled water or a unique liquid combined with finely ground ceramic powders, the material is formed, burned, and left translucent to resemble the structure of teeth. In dental laboratories, some are created by burning dental porcelains on refractory dies.[22-24]

VI. Materials Used For Cementation

Purpose and Mechanisms of dental luting cements:

- Function: Designed to retain posts and cores, restorations, and appliances, in a stable and position which will last longer in the mouth.
- Mechanisms: Retention can be mechanical (friction), chemical, and micromechanical (hybridized tissue), often a combination depending on the cement and substrate.

Types and Properties:

-Varieties: Include non-resin-based and resin-based cements

- Requirements: Must resist dissolution, provide strong bonds through mechanical adhesion and interlocking, have high tensile strength, is biologically compatible and have good handling properties.

Selection and Performance:
- Complexity: Selecting the proper cement has become more complicated due to the increase in materials for indirect restorations.
- Critical Factors: The right cement is crucial for sealing restorations, supporting retention, and achieving esthetic outcomes, especially for all-ceramic restorations.
- Properties: Optimal film thickness is 5-25 μm, with viscosity and ease of handling important for proper seating. Resin cement needs isolation due to moisture sensitivity and should have low water sorption to prevent expansion.[25-27]

Historical and Modern Developments:
- Adhesive Dentistry: Buonocore laid the foundation, while Nakabayashi and colleagues described the hybrid layer, achieving bond strength values of 20-30 MPa or higher.
- Surface Preparation: Techniques include acids, particle abrasion, adhesives, and chemical couplers like silane for optimal bonding.

Advances and Clinical Implications:
- Adhesion: Advances in adhesion monomers and surface preparation allow strong resin bonds to metals and porcelains, enhancing retention, marginal adaptation, microleakage prevention, and fracture resistance.
- High-Strength Ceramics: Bonding to aluminum oxide and zirconium oxide ceramics requires different techniques from silica-based ceramics.
- Intraoral Repairs: Strong resin bonds and surface treatments are essential for repairing chipped or fractured veneering ceramics.

Challenges and Solutions:
- Deficient Polymerization: Affects physical and mechanical properties, reducing bond strength.
- Laboratory vs. Clinical Performance: Improved clinical performance was seen with adhesive resin cement over traditional zinc phosphate.
- Setting Time Issues: Self-curing composites take about four minutes to set, causing difficulties in keeping inlays in place and ensuring moisture control. Finishing margins before setting can disturb the restoration seating.[28]

VII. Overlays

Minimally invasive dentistry is a growing field in modern restorative dentistry, driven by advancements in adhesive materials and techniques. This shift focuses on biological, adhesive, and biomimetic approaches rather than conventional mechanical retention. Lithium disilicate stands out among these new materials for its high mechanical strength, satisfactory medium and long-term survival, and excellent optical properties. This versatility makes it the gold standard for indirect restorations in the posterior sector, including use in the esthetic anterior sector and as monolithic inlays in posterior teeth. Its biomechanical characteristics allow working in minimum thickness values of 0.7 mm in the posterior sector without compromising strength.[29,30]

Despite these advances, full-coverage crowns remain the most common fixed prosthodontic treatment in the posterior sector. However, they come with significant drawbacks, including substantial tooth structure loss and potential post-prosthetic complications such as the need for endodontic therapy, tooth weakening, root fracture, and possible extraction. These restorations, including overlays, provide cuspid protection while preserving healthier tooth structure. Overlays cover all posterior tooth cusps with direct or indirect restorative material and are especially recommended for cusps thinner than 2 mm in vital teeth or 3 mm in non-vital posterior teeth.[31]

Overlays are effective for various clinical situations, such as cuspid coverage of endodontically treated teeth, managing teeth prone to fracture due to significant tooth structure loss, restoring large occlusal surfaces compromised by wear or erosion, and treating cracked tooth syndrome. Studies indicate that overlay restorations can eliminate cracked tooth syndrome symptoms without requiring endodontic treatment in most cases.[29,31,32]

The success of overlay restorations relies on bonding and luting agents, materials like dental ceramics and resin-based composites, and preparation designs that maximize tooth structure preservation and minimize stress. Adhesive indirect restorations, including overlays, have demonstrated success rates comparable to full crowns, often exceeding 90% survival rates. The primary failure modes include ceramic and tooth fractures, decementation, and caries leakage. However, their survival rate and overall performance, especially when bonded correctly and using modern adhesive technologies, provide a compelling case for their use in posterior restorations.[33-35]

Preparation Design for Overlays

Conventional crown preparations often involve removing 70-75% of tooth structure, while overlay or onlay preparations remove only 32-47%, preserving more of the natural tooth. Traditional designs were aimed at mechanical retention and required significant tooth structure removal. Modern overlay preparations focus on morphological considerations to optimize bonding, minimize dentin exposure, and enhance stress distribution. Key principles include a simple geometry with uniform occlusal reduction, smooth transitions, and ending preparation margins in enamel for a stable bond.

Overlay preparations should maintain a structure known as the "compression dome" and the "bio-rim" to manage occlusal forces effectively. The compression dome refers to the tooth enamel above the maximum contour line that receives compressive forces. The bio-rim, extending from this line to the cemento-enamel junction, bears tensile forces and is crucial for stress mitigation. Preserving these areas enhances the tooth's resistance to fracture and maintains the integrity of the restoration.

Studies highlight the importance of preserving enamel at the periphery of overlay preparations to resist deformation and ensure longevity. Unlike full-coverage crowns, overlay preparations do not diminish the dentin-enamel complex below the maximum contour line, helping prevent cracks from propagating into the root and maintaining a healthier tooth structure.[36-38]

Biomimetic Considerations

Biomimetic dentistry aims to preserve the tooth's natural structures, particularly those biologically supporting the tooth under stress. This approach aligns with the natural biomechanics of the tooth, enhancing the longevity of both the restoration and the tooth. Overlays, as biomimetic restorations, offer advantages such as working in harmony with natural tooth biomechanics, extending the tooth's restorative life cycle, and maximizing ceramic materials' fracture resistance.[39]

Comparison of Inlays, Onlays, and Overlays

Dental Filling

- Size: Varies, depending on tooth decay position.
- Function: Treats early-stage tooth decay, preventing its spread.
- Production: Filled directly at the dental office.
- Durability: Fast treatment but less durable than inlays, onlays, and overlays.
- Cost: Low price.

Inlay

- Size: Small, covering only the central point of the treated tooth.
- Function: Suitable for severe caries with large cavities.
- Production: Impressions sent to a lab; includes design, milling, contouring, and staining.
- Durability: High durability due to porcelain material.
- Cost: Similar to one complete tooth.

Onlay

- Size: Larger than inlays, covering the central point and part of the cusps.
- Function: Suitable for severe caries spreading to the cusp or slightly chipped teeth.
- Durability: Similar to inlays.

Overlay

- Size: Almost the same as a complete denture, often compared to crowns.
- Function: Replaces severely damaged teeth while retaining good working roots.
- Durability: High durability due to comprehensive coverage.

Overall, overlays are a highly effective, conservative treatment option for posterior restorations, preserving significant amounts of natural tooth structure while providing necessary protection and support. Their design and application align with the principles of biomimetic dentistry, ensuring a long-lasting and biomechanically compatible restoration.

VIII. Veneers

Veneers are tooth-colored materials applied to teeth to restore defects and intrinsic discolorations. They can be made from composite, porcelain, or pressed ceramic materials.

Types of Veneers

1. Based on Tooth Preparation:

- Partial Veneers: For localized defects or intrinsic discoloration.
- Full Veneers: For intrinsic staining or generalized defects covering most of the facial tooth surface. Factors like patient age, occlusion, tissue health, tooth position, and oral hygiene must be evaluated.

2. Based on Fabrication Method:
- Direct Veneers: Composite resin veneers applied freehand.
- Indirect Veneers:
- Conventional Powder-Slurry Ceramic: Layered on the refractory die.
- Heat-Pressed Ceramic: Melted and pressed into a mold using the lost wax technique (e.g., IPS Empress 1 and 2, OPC).
- Machinable (CAD/CAM) Ceramics: Created using CAD/CAM technology (e.g., CEREC).

Case Selection
- Indications:
1. Correcting tooth position or shape alterations.
2. Changes in tooth morphology.
3. Diastemas closure
4. Repairing incisal fractures.
5. anterior restorations which are extensive
6. Non-Carious Lesions (attrition, abrasion, abfraction).
7. Changing color of the tooth
8. rehabilitation for developing anterior guide
9. Repairing crowns and bridges.

- Contraindications:
- Inadequate enamel or tooth structure (e.g., amelogenesis, dentinogenesis imperfecta).
- root canal-treated teeth or Large existing restorations with minimal tooth structure.
- Oral habits causing excessive interdental spacing or excessive stress
Procedure for shade selection
- Key tips for shade selection:
- Perform shade matching early in the appointment to avoid color fatigue.
- Use neutral-colored drapes, remove patient makeup, and clean teeth.
- Match shades at 5-second intervals to prevent eye fatigue.
- Use canines as reference points.
- Grind off the shade tabs with darker neck.
- When in doubt, select a shade with lower chroma and higher value.
Tooth Preparation
- Need for Preparation:
- finish line needs to be definite
- should Provide space for veneer.
- Expose fluoride rich layer .
- for better retention Create a rough surface
- Recommended Preparation:
- Conservative intra-enamel preparation with 0.3-0.5 mm facial enamel reduction.
- Finish line close or at the gingival margin.
- Avoid sharp internal angles, especially at the incisal edge.
- Ensure a path of insertion free from undercuts.[40-43]

IX. Conclusion

Importance of Esthetics in Dentistry
- Esthetics is now a respected term in dentistry, previously overshadowed by function, structure, and biology.
- Successful treatment planning must prioritize esthetic impact to avoid poor outcomes.
- Interdisciplinary treatment planning should start with clear esthetic objectives and consider function, structure, and biology for optimal dental care.

Minimally Invasive Dentistry
- Despite the long-standing concept of minimally invasive dentistry, current trends sometimes sacrifice tooth structure for esthetics.

- Increased patient awareness highlights the need for responsible esthetics, emphasizing minimal intervention and treating disease before resorting to surgery.
- Maintaining healthy tooth structure through minimal intervention improves overall oral health.

Advances in Dental Materials
- Innovations in ceramic, composite, and adhesive technology have produced a range of indirect tooth-colored restorations.
- These restorations are ama alternatives to direct composites, especially for large restorations, and are more conservative than full coverage options.
- Success with these materials requires correct case selection, skilled operators, and detailed attention to the technique-sensitive nature of the procedures.

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