Egyptian Prosthodontic Association (EPA Newsletter)

Advances in Biomimetic Prosthodontics: Enhancing Fracture Resistance with Innovative Materials and Minimally Invasive Techniques

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Introduction

Endodontically treated teeth are inherently more susceptible to fractures due to the removal of pulp tissue and the subsequent loss of moisture and elasticity in the dentin. The structural changes that occur after endodontic treatment can significantly reduce the tooth's ability to withstand occlusal forces, making it crucial to employ restorative materials and techniques that enhance fracture resistance.

The biomimetic concept in dentistry emphasizes the replication of natural tooth structure and function through the use of advanced materials and techniques. This approach is particularly significant in the context of endodontically treated teeth, which often face structural integrity and fracture resistance challenges.

Integrating biomimetic principles in restorative dentistry enhances the mechanical properties of restorations and aligns with the minimally invasive and conservative treatment philosophies that prioritize the preservation of healthy tooth structure. The use of fiber-reinforced composites (FRCs) has emerged as a promising solution in this regard.

These materials, which incorporate short fibers into a resin matrix, provide improved mechanical properties, including increased tensile strength and toughness, thereby effectively mimicking the natural dentin's ability to absorb and distribute stress and glass ceramics for enamel restoration. These materials are designed to replicate the mechanical behaviour of natural teeth, allowing for better stress distribution and reduced risk of crack propagation.

Materials Used for management of endodontically treatment teeth:

1. Short Fiber-Reinforced Composite (SFRC):

O **Properties**: Offers improved flexural strength, toughness, and fatigue resistance compared to traditional composites.

O **Examples:** Materials like EverX Posterior (GC) or Fibre-reinforced Composite (Voco).

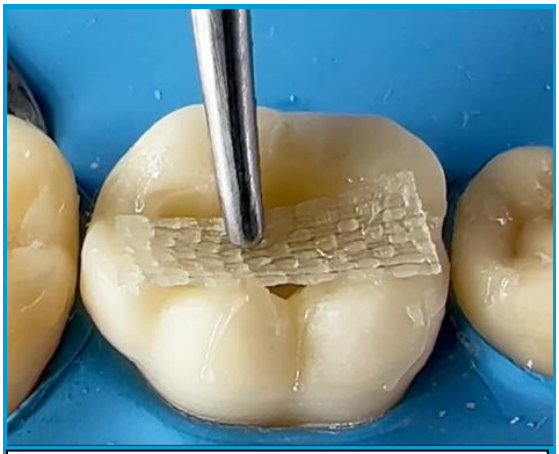

Figure (1) : Ribbond fiber.

Figure (2): Cavity after caries removal and sandblasting with 25mircron with intraoral sandblaster.

2. Polyethylene Fibers:

O **Properties:** Enhances tensile strength and provides reinforcement to the composite, reducing the risk of crack propagation as shown in Figure (1).

O **Examples:** Ribbond or FibreKor.

3. Ceramic Overlay:

O **Properties:** Provides a hard, wear-resistant surface that mimics the natural enamel.

O **Examples:** Lithium disilicate ceramics like IPS e.max.

Minimally Invasive Prosthodontics

Minimally invasive prosthodontics aims to preserve as much of the natural tooth structure as possible while providing effective restorative solutions. This approach is particularly beneficial for endodontically treated teeth, where the remaining tooth structure may be compromised.

Defect-Oriented Tooth Preparation

Defect-oriented tooth preparation is a clinical approach that focuses on addressing specific defects in the tooth structure while preserving as much healthy tooth tissue as possible. This method is particularly relevant in restorative dentistry, especially for endodontically treated teeth, where the remaining tooth structure may be compromised. This technique involves:

1. Assessment:

O Conduct a thorough clinical and radiographic evaluation to identify the extent of decay or damage.

O Use diagnostic tools such as transillumination or cone-beam computed tomography (CBCT) to assess the internal structure of the tooth.

2. Evaluate the Extent of the Defect:

Identify the size and location of the defect. This includes assessing the depth of caries, cracks, or structural loss.

3. Selective Removal:

O Remove only the defective or decayed portions of the tooth while preserving healthy dentin and enamel.

O Utilize conservative preparation techniques, such as air abrasion or laser dentistry, to minimize trauma to the surrounding tooth structure.

4. Material Application:

O Apply the previously discussed SFRC and polyethylene fibres to the prepared areas, ensuring a strong bond and reinforcement.

O The use of adhesive materials allows for a more conservative approach, as they can bond to the remaining tooth structure without the need for extensive mechanical retention.

Figure (3): Application of ever X composite in order to increase fracture resistance and acts as dentine to inhibit crack propagation.

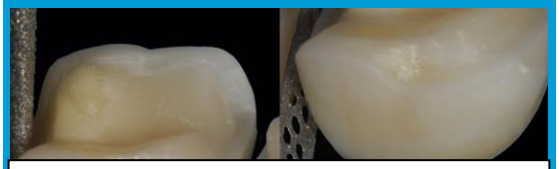

Figure (4): Morphological tooth preparation.

Figure (5): Ceramic overlay try-in.

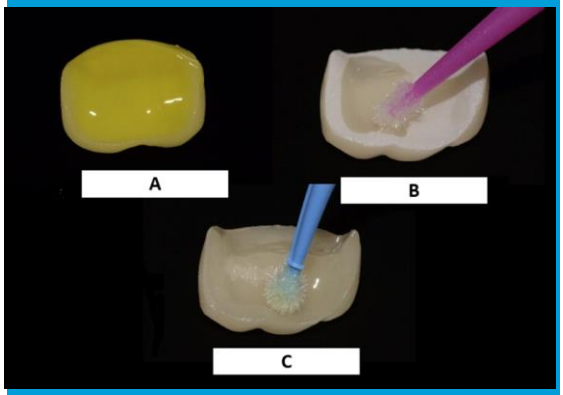

Figure (6): A Hydrochloric acid application, B Silan coupling agent application, C Application of thin layer of bonding agent.

5. Final Restoration:

O Complete the restoration with a ceramic overlay, ensuring that the final contour and occlusion are optimized for function and aesthetics.

Clinical Steps and Procedures

1. **Tooth Preparation**

• **Assessment:** Conduct a thorough clinical and radiographic evaluation of the endodontically treated tooth to assess the extent of damage and the remaining tooth structure.

• **Preparation**: caries removal and intraoral sandblasting to make micromechanical tags to enhance bonding as shown in Figure (2)

2. Material Application

• Bonding Agent:

O Select a suitable bonding agent compatible with both the composite and the tooth structure (e.g., Kuraray SE bond).

O Two-bottle system separates the primer and bonding agent, allowing for a more controlled application. The primer is applied first to enhance the wetting of the tooth surface, followed by the bonding agent, which forms a durable bond with the restorative material.

• SFRC Application:

O Application of Ever X posterior composite onto the tooth. Use a small increment technique to ensure proper adaptation and minimize voids as shown in Figure (3).

3. Curing

• Light Curing:

O Use a dental curing light (e.g., Bluephase or Elipar) to polymerize the composite. Follow the manufacturer's recommended curing times (typically 20-40 seconds per layer).

4. Ceramic Overlay preparation.

• Morphological tooth preparation within the extent of the defect following occlusal anatomy with 1 to 1.5mm occlusal clearance as shown in Figure (4).

• **Impression:**

O Retraction cord was packed proximally and Intraoral scanning IOS was used using Trios 3 scanner to scan tooth preparation after finishing and polishing of the tooth then the STL file was sent to the lab for designing and milling if overlay e-MAX CAD.

• Try in and cementation:

O Ceramic overlay was checked for fitting, shade, occlusal and proximal contacts as shown in Figure (5).

O Bonding protocol: The inner surface of the IPS e-max CAD restorations was etched for 20 seconds with 5 % hydrofluoric acid. The etched inner surfaces were thoroughly washed with water spray, dried with oil-free compressed air, and then

Figure (7): Tooth surface preparation and cementation.

silanized for 60 seconds, followed by applying a thin layer of bonding agent as shown in Figure (6).

The enamel margins of all prepared teeth were selectively etched for 20 seconds using 35% phosphoric acid. Following a water spray rinse, compressed air was used to dry the etched surfaces. A bonding agent was applied to the enamel and dentine as shown in Figure (7).

Duo-Link resin cement was auto-mixed and inserted directly into the cavity of the prepared teeth. After seating of the EMAX overlay micro brush was used to remove extra cement. Before the final curing, an air barrier (K-Y Jelly, Johnson & Johnson) was applied to all margins.

5. Finishing and Polishing

• **Finishing:**

O Use ceramic rubber cups to ensure that the margins are smooth.

Comparison with Ceramic Endo Crown

• **Fracture Resistance:** Research indicates that the combination of SFRC and polyethylene fibres significantly enhances the fracture resistance of endodontically treated teeth compared to traditional ceramic endo crowns. Studies have shown that SFRC restorations can withstand higher occlusal forces and exhibit less crack propagation.

Conclusion

The integration of short fiber-reinforced composites with polyethylene fibres and ceramic overlays represents a promising advancement in biomimetic prosthodontics. Coupled with the principles of minimally invasive prosthodontics and defect-oriented tooth preparation, this approach not only improves the mechanical properties of restorations but also enhances aesthetic outcomes for patients, making it a reliable choice for restoring endodontically treated teeth.

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