Effect of Different Preparation Designs on the Fracture Resistance and Failure Modes of Polymer Infiltrated Ceramic Endocrown Restorations

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Dedication

This work is dedicated to

My beloved parents

Dear husband

Lovely daughter

My sisters & my brother

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The primary reason for performing endodontic therapy is the preservation of teeth and preventing their loss. However, endodontic treatment renders them more susceptible than vital teeth to biomechanical failure because of the access preparation. [1; 2] Also, loss of structural integrity of endodontically treated teeth caused by several reasons such as caries or trauma results in reduction in the fracture resistance and stiffness of such teeth. Compared to vital teeth, endodontically treated teeth undergo increased cuspal deflection during loading and then delayed recovery upon removal of the load leading to crown fractures. [3; 4; 5]

This biomechanical alteration inflicts a negative impact on the long-term prognosis of the tooth and therefore the rehabilitation of endodontically treated teeth is considered to be challenging. [3; 6] Generally, the clinical survival of restored teeth is dependent on the restorative material, technique, remaining tooth structure, and the interactions between material, teeth, and the oral environment. [7] This means that the amount of sound tooth structure that will remain following root canal therapy and any subsequent preparation is an important factor in planning the restoration of endodontically treated tooth. [8]

To date, there is still no clear agreement in the literature about which material or technique can restore endodontically treated teeth optimally. [9] The classical approach for restoring endodontically treated teeth is to build up the tooth with a post and core, utilizing adhesive procedures and placement of full-coverage crowns with a sufficient ferrule. [6; 10] This technique though successful had many disadvantages leading to other alternative suggestions such as endocrowns.

The endocrown is a "one-piece ceramic construction comprising a circumferential butt margin and a central retention cavity inside the pulp chamber and constructs both the crown and core as a single unit". The main advantages of such approach is utilizing the available surface in the pulp chamber to improve retention through adhesive bonding in addition to conservatism by following the concept of decay-orientated design. [11; 12]

An important area of interest is the choice of the restorative material. Materials with mechanical properties similar to those of sound teeth improve the reliability of the restorative system. [13] Polymer infiltrated ceramics have been suggested recently as a hybrid material combining the properties of ceramic and polymer forming what's called double network hybrid ceramic material. [14] Their efficiency in the construction of different types of restorations and specially endocrowns is worth a trial.

Little information have been available regarding variation of basic preparation guidelines for restoring endodontically treated teeth using endocrown restorations milled from the recently introduced ceramic materials in an attempt to improve their fracture resistance. It's important that factors such as the extension of the finish line and the occlusal thickness of the restoration will be further investigated in order to get more information about their potentials for clinical use.

- **Restoration of endodontically treated teeth:**

Recently, the growing appreciation of the importance of maintaining teeth vitality and the increased knowledge about the high risk of biomechanical failure of endodontically treated teeth have led to considering the concept of minimally invasive dentistry more than ever before.

It was proposed repeatedly by several studies that the dentin in endodontically treated teeth is different from that of vital teeth assumingly due to water loss and loss of collagen crosslinking. [15] **Sedgley and Messer (2002)** [16] tested the biomechanical properties of dentin of endodontically treated teeth and vital teeth of contralateral side and concluded that endodontically treated teeth are not more brittle. It's worth mentioning that although the loss of tooth vitality is not accompanied by significant change in tissue moisture or collagen structure, endodontic therapy, and, in particular, the use of irrigants such as sodium hypochlorite and chelators, proved to soften dentin. [6]

Alteration in the biomechanics of endodontically treated teeth are mainly due to tissue loss caused by previous pathologies (caries, fracture, cavity excavation), endodontic treatment (access cavity, root canal shaping), and invasive restorative procedures (post placement, crown fabrication). [6] It was found that conservative access cavity preparation reduces tooth stiffness by only 5%, but loss of marginal ridges causes more reduction. It was reported in literature that reduction in tooth stiffness following occlusal and mesio occlusal distal (MOD) cavity preparations is 14% to 44% and 20% to 63% respectively. [17] Also, lack of neurosensory feedback mechanism following teeth devitalization results in poor protection mechanisms of such teeth.

When the devitalization of teeth is inevitable, a successful clinical prognosis of these endodontically treated teeth depends mainly on adequate root canal treatment followed by proper restorative treatment. [18] The main objectives of a restoration following root canal treatment are restoring function and esthetics and preventing bacterial micro-leakage into the root canal system. [19] Also, it is important for periodontal health and protection of residual tooth structure against fracture. [19] Inadequate restoration of endodontically treated teeth may lead to coronal micro-leakage followed by failure and extraction of such teeth in about 60% of the cases making the time factor very important and final restorations should follow as soon as possible. [20; 21]

The restoration of endodontically treated teeth is considered to be challenging mainly because of the structural differences between vital and non-vital root canal filled teeth. It has long been guided by empirical rather than biomechanical concepts. Despite the fact of the abundance literature concerning this issue, still the controversy and empiricism found cannot be neglected. This is complicated by the wide available range of restorative materials and techniques and the lack of accepted clinical standards regarding the best method of non vital teeth restoration. [6] Focusing on the relevant advantages and disadvantages of different available techniques may offer some help for the clinician to choose the proper restoration. (19)

Minimal loss of coronal tooth structure relates to teeth that had minimal or no restoration but require root canal treatment. The remaining tooth structure should present only minimal loss in strength compared to a vital tooth, provided that there are no horizontal or vertical cracks, the endodontic access cavity and enlargement of the pulp chamber minimally are considered not to significantly affect tooth biomechanical properties. (22; 23) The authors proposed treating such teeth with adhesive restoration filling the access cavity and pulpal chamber only with the choice of material limited to composite resins, in combination with an effective adhesive system. (24) This conservative approach is contraindicated in patients with parafunctional habits, group guidance and steep cuspal inclination, which may require complete occlusal coverage. (22)

In cases where up to one half of the coronal tooth structure is missing, the coronal structure is enough to provide restoration retention and strength, teeth with existing medium-sized restorations that require root canal treatment do not need a post-core restoration. Complete occlusal coverage, such as an endocrown or onlay restorations, is proposed. (6) But when more than half of the coronal tooth structure is missing, the surface available for adhesion is limited. In such case, post-core restoration is obligatory to ensure resistance of the restoration to fracture. A ferrule effect should be attained by extending restoration margins 1.5-2.0 mm below the foundation limits. However, this option is