The Effect of Different Occlusal Preparation Designs on the Fracture Resistance of two All–Ceramic Crowns Restoring Endodontically Treated Teeth

A thesis submitted for the partial fulfillment of the Master Degree requirements in Crown & Bridge, Faculty of Dentistry, Ain Shams University

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2015

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Introduction

The dental profession continues to advance in restorative dentistry to reach highly esthetic, strong, and conservative solutions.[1] Restoration of endodontically treated teeth is one of the most challenging topics as endodontically treated teeth suffer from decrease in strength ,retention for restoration and esthetics .There are many choices for restoring endodontically treated teeth such as post and core either readymade or custom made, following this step ,the role of full crowns become obvious .

Esthetic problems are not less important than mechanical problems facing the dentist while seeking patient's satisfaction. Therefore the dentist must restore the endodontically treated teeth without compromising esthetics.

With a variety of esthetic materials available for tooth restoration today, it is important that the clinician understands the tooth reduction requirements for each material option, in order to maximize the esthetic value and functional strength of the completed restoration.[2] Dental prosthetic treatments follow principles based on preserving sound tissue. To prevent tooth weakening, there is a need for a minimally invasive preparation of natural tooth structure. Modern adhesive technologies and high strength ceramic materials with enhanced fracture toughness facilitate the development of minimally invasive preparation techniques.[3]

The profession constantly strives to improve the strength, longevity, and esthetics with all restorations. Preparation of endodontically treated teeth to receive full crowns may have different occlusal preparation designs either flat surface, in two planes or to follow the occlusal anatomy. Dentist should be aware for the effect of each design on each crown material to ensure a more durable restoration.

The purpose of this in vitro study is to evaluate and compare the effect of different occlusal preparation designs on full all ceramic crowns of different materials from aspect of fracture resistance and strain gauge analysis in order to decide which type of occlusal reduction may enhance durability of full crowns constructed on endodontically treated teeth.

The problem is information about the effect of occlusal preparation designs on the fracture resistance of different ceramic crowns is limited.

Review of Literature

1. Endodontically treated teeth:

If the endodontically treated teeth were considered more brittle, in the past, due to structural change in the dentin, which lost water and collagen cross-linking after the endodontic treatment , actually it is known that loss of structural integrity associated with the access preparation results in increased cuspal deflection during function, which leads to a higher occurrence of fractures.

Considering that in most endodontically treated teeth there are missing tooth structure caused by caries or existing restorations associated to endodontic access preparation, it is difficult to establish if higher occurrence of fractures is depending on the structural change in the dentin, missing of tooth structure or both.[4]

Steven A. Aquilino et al, [5] performed a retrospective clinical study on crown placement and the survival of endodontically treated teeth. The study involved 33 incisors, 25 canines, 72 premolars and 73 molars, the survival rate of crowned teeth in general were about 6 times more than the uncrowned teeth throughout a period of 11 years.

Another factor to be considered when selecting materials and techniques while restoring endodontically treated teeth is the tooth placement in the arch due to difference in forces in anterior and posterior regions.

Chan CP et al. [6] performed a survey on 315 Chinese patients to evaluate the liability of vertical root fracture of teeth of different types. It was found that the mandibular first molars were more than 2 times higher in incidence of fracture than maxillary first molars and all premolars. This was attributed to heavier masticatory forces on thin flat roots.

Dimitriu et al, in 2009 [7], investigated the current considerations concerning endodontically treated teeth as the alteration of hard dental tissues and biomechanical properties following endodontic therapy. They presented an overview of the current knowledge about composition and structural changes and also about specific biomechanical alterations related to vitality loss or endodontic therapy. They concluded that vitality loss or endodontic procedures seem to induce only negligible changes in hard dental tissue moisture. Physico-chemical properties of dentine can be modified by some of the endodontic chemical products used for chemo-mechanical debridement. On the other hand, tooth biomechanical behavior is affected since tooth strength is reduced proportionally to coronal tissue loss, due to either pre-existent carious/non-carious lesions or cavity access preparation besides restorative procedures.

2. Full coverage restorations:

Full-coverage dental restorations are integral part of fixed prosthodontics. The reasons that compel patients to seek any type of dental restorations including inlays, onlay, veneers and crowns, could be divided into the following: 1) Dental disease including caries or periodontal causes, 2) Trauma such as accidents and 3) Esthetics to improve the appearance of their smile. The number of crowns delivered in a prosthodontic practice is high because their use can be incorporated into any treatment plan with any combination of teeth, dental implants and removable prostheses.

Throughout the years, crowns have been the restoration most studied with regard to longevity, causes of failures, materials, and techniques; thus, there is some evidence to support their successful clinical use.

2.1 Materials used for full-coverage dental restorations:

The restorations that prosthodontists use in clinical practice include full coverage crowns, veneers, onlays, inlays and fixed partial dentures. Along with the diversity of the restoration type, comes the diversity of materials used to produce each one of those types. Many materials have been used throughout the history of fixed prosthodontics, and each one presents its own indications, advantages and disadvantages. Currently, based on the most commonly used materials, restorations could be categorized as cast veneer, metal-ceramic and all-ceramic.

With the constant increase in the cost of gold, silver and the difficulty of working with non-precious and titanium alloys, the dental laboratory industry has been looking for alternative dental materials for many years.

Moreover, absence of translucency is still a drawback when choosing ceramo-metallic as a crown material even after masking the grayish shade of metal coping by opaque porcelain, this is because ceramo-metallic restorations can only reflect or absorb light leading to a limitation for the superior esthetic results especially when a clear tooth color is needed.

In pursuit of superior esthetics and biocompatibility, the use of ceramic materials evolved and its use increased in clinical practice and research.[8] Dental ceramic materials exhibit many desirable material properties, including biocompatibility, esthetics, diminished plaque accumulation, low thermal conductivity, abrasion resistance, and color stability.[9]

3. __Dental Ceramics:__

Ceramics are not considered new materials as they were in use more than 10,000 years ago during the Stone Age.[10] They play an integral role in dentistry. Their use in dentistry dates as far back as 1889 when **Land** patented the all-porcelain "jacket" crown. This new type of ceramic crown was introduced in 1900s. The procedure consisted of rebuilding the missing tooth with porcelain covering, or "jacket" as **Land** called it. The restoration was extensively used after improvements were made by Spaulding and publicized by **Capon**. While not known for its strength due to internal micro cracking, the porcelain "jacket" crown (PJC) was used extensively until the 1950s.[11]

A resurgence of an all-ceramic restoration came in 1965 with the addition of industrial aluminous porcelain (more than 50%) to feldspathic porcelain manufacturing.

McLean and Hughes developed this new version of the porcelain jacket crown that had an inner core of aluminous porcelain containing 40% to 50% alumina crystals.[12] Although it had twice the strength of the traditional PJC, it still could be used in the anterior region only (due to its low strength). Its higher opacity was also a major drawback.[13]

Another development in the 1950s by **Corning Glass Works** led to the creation of the castable Dicor® crown system. Glass was strengthened with various forms of mica.

The process involved the use of the lost-wax casting technique, which produced a casted glass restoration. Then, this was heat-treated or "cerammed" .The ceramming process provided a controlled crystallization of the glass that resulted in the formation and even distribution of small crystals. Examples of different crystalline formations are leucite, fluoromica glass, lithium disilicate, and apatite glass ceramics.[14]

The crystal formation increased the strength and toughness of the glass ceramic. The processing difficulties and high incidence of fracture were factors that led to the abandonment of this system.[11]

During this time, a glass-infiltrated ceramic core system was developed. This glass-infused alumina core had a flexural strength of 352 MPa.[15] To increase the translucency and esthetics, Vita replaced the sintered alumina with spinel ($MgAl_2O_4$).Vita also added another variation of the infused core by mixing alumina with zirconium oxide crystals, which increased the flexural strength to 700 MPa. It was intended for posterior crowns and bridges.

In the mid-1990s Nobel Biocare introduced the Procera® AllCeram core, which was the first computer-aided design/computer-aided manufacture (CAD/CAM) substructure. This core consisted of 99.9% Alumina to which a feldspathic ceramic was layered.

Parallel to the introduction of infiltrated ceramics, two glass-ceramic compositions were introduced: leucite based (IPS- Empress, IvoclarVivadent, Liechtenstein) and lithium disilicate based (IPS-Empress II, IvoclarVivadent, Liechtenstein). Leucite was first added to feldspathic porcelains to raise the coefficient of thermal expansion to match the metals to which they were fired.

The crystalline leucite phases also helped feldspathic porcelain to slow crack propagation. High leucite-containing ceramics Empress® I and