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# FRACTURE RESISTANCE OF ENDODONTICALLY TREATED PREMOLAR TEETH RESTORED WITH CAD/CAM LITHIUM DISILICATE ENDOCROWNS AND H-SHAPED POST : IN VITRO STUDY

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*ABSTRACT*

**Aim:** This study was conducted to compare the fracture resistance of lithium disilicate endocrowns with circular post and endocrowns with H-shaped short post when bonded to endodontically treated premolar teeth.

**Materials and Methods:** A twenty two extracted single rooted premolars (specimens), were divided into two equal groups (11 specimens in each group). Group H : restored with endocrowns with H- shaped post. Group C : restored with endocrowns with circular post. Teeth were scanned with DOF scanner and restorations were designed with EXOCAD software. All restorations were milled with imes-icore machine. The endocrowns were cemented on their corresponding teeth using BisCem (Bisco Inc., Schaumburg, IL, USA) dual-cure adhesive resin cement following total etch technique protocol. All samples were subjected to fracture resistance testing using universal testing machine. After facture testing, fracture patterns and failure mode of all samples were examined visually and photographically by digital camera. Data were collected and statistically analysed.

**Results:** Independent t test revealed that endocrowns with H-shaped post (Group H) showed higher fracture resistance values (1374.6 ±313 N), compared with endocrowns with circular post (Group C) (1107.9 ± 205 N). Chi square test showed no statistically significant difference between groups in mode of failure.

**Conclusion :** Lithium disilicate endocrowns with H-shaped post provide promising design in premolar region. Design of post of endocrown has no effect on mode of failure.

## INTRODUCTION

Rehabilitation of endodontically treated teeth with large coronal destruction is still a clinical challenge, especially due to the loss of strength characteristics associated to the removal of pulp and surrounding dentin tissues. Coronal retention of the restoration is usually compromised, thus intraradicular posts combined or not with core materials may be

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required. Despite all clinical success achieved with the use of intraradicular posts, one disadvantage of this system is the additional removal of sound tissue needed for fitting the post into the root canal; additionally, this procedure was revealed to affect the overall biomechanical behavior of the restored teeth. Alternatively, other restorative approaches have been suggested, including but not limited to the well-known endocrown restorations. [1–3]

Endocrowns assemble the intra radicular post, the core, and the crown in one component, thus representing monoblock restorations. Different from conventional approaches using intraradicular posts, endocrown restorations are anchored to the internal portion of the pulp chamber and on the cavity margins, thereby resulting in both macro- and micro mechanical retention, provided by the pulpal walls and adhesive cementation, respectively. In addition, endocrowns have the advantage of removing less amounts of sound tissue compared to other techniques, and with much lower chair time needed. Moreover, the masticatory stresses received at the tooth/restoration interface are more properly dissipated along the overall restored tooth structure when endocrowns are placed. [4-6]

In single rooted premolar teeth the modification of the intracoronal restoration anchorage profile may be a valid concept to improve the retention and fracture resistance, given that the materials are adjusted for this purpose in terms of mechanical resistance and internal adaptation. [7]

## MATERIALS AND METHODS

### I-Teeth Selection:

Twenty two caries free recently extracted human single rooted premolars were selected for the study. The anatomic crowns were selected to be with similar dimensions, the buccolingual (9 ± 1 mm) and mesio-distal (7 ± 0.5 mm) at height of contour. The root lengths were (13± 0.5 mm).

### II. Teeth disinfection and storage

The selected teeth were disinfected by immersion in 5 % sodium hypochlorite for 15 minutes at room temperature. The teeth were then kept hydrated at room temperature in saline solution prior to the study.

### III. Teeth mounting

All teeth were mounted in epoxy resin blocks in vertical direction up to 2 mm below the CEJ (simulated bone level) and hold in position till complete polymerization of the resin using parallelometer device.

### IV. Preparation of the teeth:

#### 1- Decapitation of teeth:

The crowns of the collected teeth were decapitated 2 mm above the cemento-enamel junction from the proximal surfaces. Sample teeth were stored in 0.9% sterile saline solution to avoid dryness.

#### 2- Endodontic treatment:

Root canals were treated using rotary system Ni-Ti using matched tapered single cone obturation technique.

#### 3- Preparation design

***A - Endo-crowns with circular post (Group C).***

After coronal decapitation to prepare a circular butt margin, gutta percha excess was removed, a thin layer of flowable composite material was applied to seal the canal entrance and to enhance the bonding of the ceramic endocrowns constructed in later stage.

The pulp chamber was prepared to eliminate undercuts with a $10^{o}$coronal divergence, with an oval shaped intrapulpal post cavity and a depth of 4.5 mm from the cavosurface margin till depth of cavity using tapered stones with round end. All internal line angles were rounded and smoothed

***B) Endo-crowns with H- shaped post*** **(Group H)**

As described in (Group C) but the pulp chamber was prepared to with an H-shaped intrapulpal post cavity.

H-shaped intrapulpal post cavity consists of :[7]

1- Web (3.4 mm length) oriented along the bucco-lingual axis of the tooth traversing the pulp chamber.

2- Two parallel flanges of the H aimed to engage the dentin buccally and lingually and were individually adapted to leave a minimal residual lateral dentin thickness of at least 1 mm.

The middle part of H-post cavity (isthmus ) was constricted and have a width of about 2mm.

The depth of the cavity was 4.5 mm from the cavosurface margin till depth of cavity. The outline of the preparation was rounded to prevent stress concentrations on sharp corners as well as facilitating endocrowns milling.

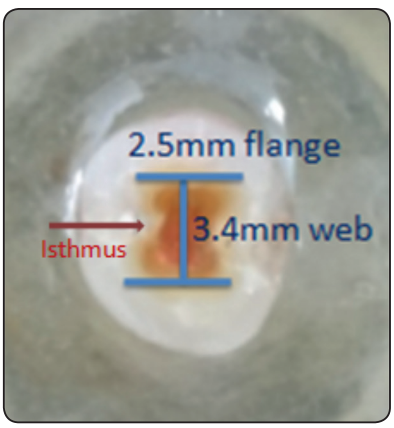


Fig. (1) Preparation of H- shaped post

## V. Construction of CAD/CAM endocrowns

### 1- Scanning and designing for both groups

To obtain a three-dimensional image for each prepared tooth on the computer screen of the EXOCAD software system the prepared tooth was scanned using DOF scanner after using reflecting powder, then the captured pictures were saved in preparation catalogue of software.

The software calculated a virtual model from the scanned pictures and automatic margin finder was used for preparation margin detection. With the aid of EXOCAD software, the scanned prepared teeth were correlated to virtual endocrown restorations with 4.5mm buccal cusp height and 4.5mm lingual cusp height in order to obtain standardized tooth from.

### 2. Milling process for both groups

The selected ceramic block of the required size was inserted in spindle of the milling chamber of the 5-axis imes-icore milling Machine and fastened with the set screw.

The milling process was fully automated without any interference with copious water cooling.

After completion of the milling process, the endocrowns were separated manually from the block holder with a diamond cutting instrument.

All endocrowns were checked on their corresponding teeth for cracking, proper seating and marginal accuracy.

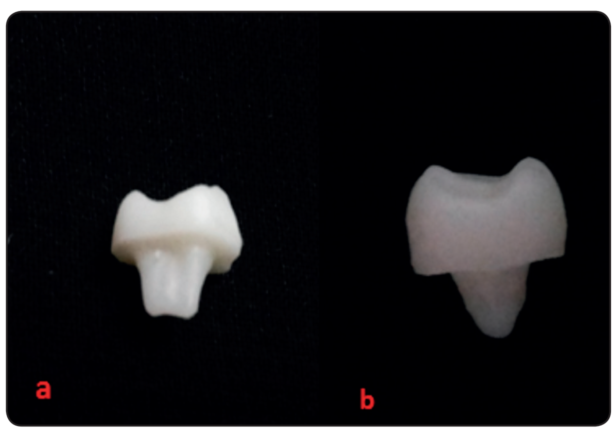


Fig. (2) Endocrown restorations after crystallization. a) Endocrown with H-shaped post. b) Endocrown with circular post

**3. Crystallization and glaze firing**

The Program at P300 furnace was used for crystallization and glaze firing. according to the manufacture's instructions.

**V- bonding procedures**

***1- Surface treatment of restorations***

**IPS e.max CAD restorations :**

Intaglio surfaces of each endocrown were treated according to the manufacturer's instructions. Etching with 4% hydrofluoric acid gel was applied for 20 seconds then rinsed for 60 seconds with running water and dried for 30 seconds with moisture-free air. Then ceramic primer containing silane coupling agent was applied to the intaglio surfaces of all endocrowns and allowed to dry for 60 seconds.

***2. Surface treatment of the prepared natural tooth***

Prepared teeth surfaces were etched with 37% phosphoric acid–Etching gel for 15 seconds, rinsed for 20 seconds, and dried with oil-free air for another 5 seconds.

Two separate coats of all-bond, were applied to the prepared teeth surface with a microbrush with no light curing between the coats. Excess solvent was then dried with oil-free air for 3 seconds, then light cured for 20 seconds

The dual cure resin cement, BisCem cement was applied on the prepared surfaces of teeth. Then each endocrown was bonded to its corresponding tooth with finger pressure, excess cement was removed immediately with a microbrush.

A customized loading device was used to apply a constant load of 3 Kg parallel to the long axis of each restoration at the centre to prevent rebounding of the restoration during cementation.Then cement was light cured at each surface for 20 seconds using light cure device according to manufacturer's instructions.

**VII. Fracture resistance determination**

Fracture test was done by compressive mode of load applied occlusally using a metallic rod with round tip (3.6 mm diameter) attached to the upper movable compartment of testing machine traveling at cross-head speed of 1mm/min.

The load at failure manifested by an audible crack and confirmed by a sharp drop at load-deflection curve was recorded using computer software (Bluehill Lite Software Instron® Instruments).

The load required to fracture was recorded in Newton. Data recorded were collected, tabulated and statistically analyzed

**Fracture Mode**

Following the fracture resistance test, fracture mode of all samples was examined visually and photographically using a digital camera.

The failure was considered unfavorable if the tooth fracture was below the CEJ ; including vertical root fracture. On the other hand, favorable fracture was defined as restorable failure if it was above CEJ.

## RESULTS

Revealed that endocrowns with H-shaped post (Group H ) showed higher fracture resistance values (1374.6 ±313 N), compared with endocrowns with circular post (Group C) (1107.9 ± 205 N ).

Independent t test showed that differences were statistically significant with P-value $\leq 0.05$.

Based on the results of mode of failure obtained, 90% of the fractures of the two groups showed catastrophic irreparable fractures, irrespective of the shape of the posts of the endocrowns

Chi square test showed no statistically significant difference between groups in mode of failure.

## DISCUSSION

Premolar teeth with extensive loss of coronal tooth structure have traditionally been restored by means of a metallic or non metallic post and crown.[8] Concerns regarding such a procedure include the risk of root perforation and the need for removal of sound tissue in the root canal to facilitate the room for the post material, thus weakening the tooth-root complex. Moreover, the benefit of a post in the root canal for the overall retention of the successive reconstruction in general is being questioned in recent years.[9]

Moreover, in restoration of premolar teeth with endocrown, it was found that by avoiding the ferrule, which is typically found in conventional crowns may cause the loss of sound enamel and dentin tissues that would be important for proper bonding of the restoration. [10]

Posterior premolar teeth used in previous studies [10] showed non-satisfactory performance and lower bond strength of premolar endocrowns with circular post in comparison to molar endocrowns under occlusal forces, which was attriburted to the small surface area of post in pulp champer ; resulting in lower bond strength.

So it was essential to study the newly introduced design for endocrown (H-shaped design) as an attempt to be of higher surface area and consequently higher mechanical properties.

Regarding the effect of different designs of intracoronal preparation on fracture strength, results obtained in this study showed that endocrowns with H-shaped post (Group H) recorded a statistically significant higher mean fracture resistance value (1374.60 N ± 313.35) than endocrowns with circular post (Group C) (1107.91 N ± 205.12). This might be attributed to the smaller adhesion area of endocrowns with circular post compared with endocrowns with H-shaped post ; since it was reported by Schmidlin et al, 2015 [7,] that the surface area affects the bond strength and consequently the fracture strength. Moreover,it was suggested that the design of the newly introducd H-shaped post might minimize the interfacial displacements by engaging the dentin. Since this cross-section which has two flanges oriented buccally and orally allows for better engagement of the remaining dentin, which results in smaller strains across the interfaces of the components of the restoration hence increasing the fracture resistance of the restoration as suggested by Schmidlin et al, 2015 [7].

These results were in agreement with Schmidlin et al [7] who reported that H-post group restored with lithium disilicate endocrowns presented higher fracture resistance compared to the classical endocrowns (endocrowns with circular post).

**Regarding mode of failure**, no statistically significant difference was found between the two groups, since 90% of the samples in both groups showed catastrophic mode of failure extending to the root, below CEJ, involving both the tooth and the restoration. This was attributed to the fact that all endocrowns were constructed from the same material ; resulting in similar failure behavior

These result were in agreement with **Schmidlin et al** [7] who attributed these rasults to the high fracture toughness of the ceramic restorations, which will result in an increase in the number of irreparable fractures. Since once a tougher ceramic material is used, the strength of the restoration increases and so does the likelihood of an irreparable failure, as the dentin will fracture ahead of the ceramic ; thus resulting in this catastrophic mode of failure.

## CONCLUSIONS

**Within the limitations of this study, the following conclusions were drawn:**

- Lithium disilicate endocrowns with H-shaped post provide promising design in premolar region.
- The modification of the shape of the endocrowns intracoronal posts might be a valid way to improve the fracture resistance, of endocrowns in the premolar region.

- All fracture resistance loads obtained were far beyond the maximum masticatory forces, indicating that both designs can withstand the maximum intraoral masticatory forces in the premolar region.
- Design of post of endocrown has no effect on mode of failure.

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