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Fracture Resistance of Endodontically Treated teeth: Effect of CAD-CAM Post-core and Endocrown materials

Mostafa Abdul Rahman Alhawari[1], Walid Abd El-Ghafar Al-Zordk[2] and Manal Mohamed Abo-Madina[3]

1*(Post Graduate Student At Fixed Prosthodonticdepartment ,Faculty Of Dentistry, Ukrainian medical stomatological academy)*
2*(Associated, Professor At Fixed Prosthodonticdepartment ,Faculty Of Dentistry, Mansoura University)*
3*(Professor At Fixed Prosthodontic Department, Faculty Of Dentistry, Mansoura University)*
Corresponding Author: Mostafa Abdul Rahman Alhawari

Abstract: ***Objectives:*** *Effect of cad-cam post-core and endocrown materials on fracture resistance of endodontically treated teeth.*
Materials and Methods: *A total of forty mandibular premolar teeth were divided into two main groups according to the restoration.* ***Group I:*** *Twenty mandibular premolar teeth restored with customized CAD-CAM Post-core.* ***Group II:*** *Twenty mandibular premolar teeth restored with customized Endocrown. Each group was fabricated from PolyetheretherKetone (PEEK) material. All groups were cemented with dual cure Rely X U200 self-adhesive resin cement. The specimens were thermocycled (7000cycle, at 55^{o}C). Then mounted in the Universal Testing Machine. Each specimen was loaded to failure at a crosshead speed 1mm/min. Mode of failure was also examined. Data were analyzed using one way analysis of variance (ANOVA) and Tukey's post hoc significance difference tests. Differences were considered significant at P<0.05.*
Results: *There was a statistically significant difference was detected between PEEK Post-core with higher mean value than Endocrown design (1863.24 & 1566.87respectively),).*
Conclusions: *Under the conditions of this study, fracture resistance load obtained in different design restored by PEEK Post-core treated mandibular premolar demonstrated significant greater failure resistance than Endocrown design.*
Keywords: *Post-core, Endocrown, PEEK, CAD/CAM, Fracture resistance.*

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I. Introduction:

Restoration of endodontically treated teeth continues to be a challenge in reconstructive dentistry. Endodontically treated teeth often have extremely thin coronal tooth structure remaining after root canal therapy and preparation for crown.As such, they require a post-core to support the definitive restoration.[1]

One of the production methods of ceramic restorations is CAD-CAM. There are different methods for preparing ceramic CAD-CAM post core systems: the core can be constructed separately and adhesively luted to post and tooth, one-piece post and core complex can be constructed, and the core can be constructed using a heat pressed technique. Using these methods, disadvantages of direct composite core might be avoided. Functional requirement is an important aspect to be considered when selecting materials and techniques to restore endodontically treated teeth because teeth are subjected to different forces. [2]

The endocrown was described for the first time by Bindle and Mörmann as adhesive endodontic crowns and characterized as total porcelain crowns fixed to endodontically treated posterior teeth. This method is particularly indicated in cases in which there is excessive loss of tissue of the crown, interproximal space is limited and traditional rehabilitation with post and crown is not possible because of inadequate ceramic thickness.[3]

PEEK is one of the organic thermoplastic polymers in the PolyArylEtherKeton family, best-known as a high-performance polymer family, The manufacturer reports that PEEK has a similar compressive strength (246 MPa) to that of dentin (297 MPa), although it has a lower elastic modulus (5.1 GPa) than that of dentin. In addition to its biocompatibility, appropriate mechanical strength, shock-absorbing ability, and a wide capability of fabrication processing including milling and pressing make PEKK an attractive dental material for the fabrication of custom-made intraradicular dental post-core systems. [4]

Therefore ,the aim of this study was to evaluate the fracture resistance of endodontically treated teeth: effect of cad-cam PEEK post-core and endocrown design.

II. Materials and methods

Tooth Collection and Preparation

Mandibular premolars will be collected following extraction from surgery department for orthodontic purpose of Mansoura University. then will be selected by visual inspection to nearly have similar dimensions. Endodontic treatment will be prepared to receive PEEK CAD/CAM endocrown and post & core restoration.

Specimen grouping:

A total of forty mandibular premolar teeth will be divided into two groups according to the restoration type into:
Group I: Teeth restored with customized PEEK CAD-CAM post-core (n = 20):
Group II: Teeth restored with PEEK customized Endocrown (n = 20):

Teeth disinfection and storage

Teeth were disinfected by immersion in 5% sodium hypochlorite for 15 minutes at room temperature. All teeth were cleaned with ultrasonic scaler with low power and under copious water and then stored in standardized saline solution at room temperature until use.

Centralizing the teeth in the epoxy resin blocks

A specially designed centralizing device was used to allow accurate centralization of the tooth during fabrication of epoxy resin blocks. The device consists of a cylindrical Teflon mold (2cm length and 2cm internal diameter) were constructed for holding the epoxy resin and the tooth inside

Removal of coronal tooth structure

Each tooth sectioned perpendicular to long axis 2mm coronal to the proximal CEJ, using a super coarse diamond disc byComputerized Numerical Control (CNC) milling machine (C.N.C Premium 4820, imes-icore, Eiterfeld, Germany)

Endodontic treatment:

Root canals were instrumented using k files no. 15 and 20 (DentsplyMaillefer, Ballaigues, Switzerland) followed by third k files after initial file is the master file when reach to full length,by step back technique then 3 H files with decrease one millimetre in each file. All canals were obturated using matched master cone. Guttapercha points (Dentsply, Maillefer, Ballaigues, Switzerland) were coated with the resin sealer (Dentsply IH Ltd, United, Kingdom) and placed in the root canals to the working length then lateral condensation. Excess guttapercha was removed using heated instrument (cherry red) then the periapical radiograph was taken to ensure the obturation

Preparation of endocrown with butt joint design:

The endodontic access cavity was prepared with butt joint design to eliminate undercuts with an internal taper of 8-10 degrees with 5mm depth and wall thickness 2mm using a tapered diamond coated stainless steel bur with a rounded end(Chamfer Endmill).

Preparation of CAD-CAM post-core with 2mm ferrule:

After endodontic treatment, Gates-glidden (Dentsply-Maillefer, Ballaigues, Switzerland) were used with rubber stopper that attached to the gates glidden to standardize the post length and remove guttapercha from the canalsMake an impression of the post space preparation with light-body addition silicon material (Zetaplus, Germany) was injected into the root canal space using a syringe, and placed a plastic post (PenJet Angelus. United States) into the canal.

The patterns (Mandibular premolar) were sprayed with anti-reflection scan powder spray (Digiscan-Spray, Yeti). Each tooth was mounted over the scanning tray of the extraoral scanner (Ceramill map400, AmannGirrbach). The scanning process was performed automatically by moving the shifting plate with the pattern fixed on it and gaining multiple camera screening **(Figure 13)**. The construction data to design the restorations was performed through standard transformation language (STL) data format. The job definition on the CAD-CAM software (Ceramill Mind software, AmannGirrbach) was started by selection of inlay-onlay as restoration type. After the software calculated the proposed design of endocrown, some modifications were made manually as the endocrown length was 5mm inside the root canal and 5mm height of the crown **(Figure 14)**. The STL file was sent to the milling unit (Ceramill Motion 2 5X, AmannGirrbach) to mill the endocrown from VitaEnamic and PEEK block**.**

Endocrown and post-core PEEKCAD-CAM fabrication

Surface treatment to PEEK:

The PEEK composite material surfaces were sandblasted with 50μm Al_2O_3 particles (Masel,USA)[5] for 15 seconds at a pressure of 0.4 MPa and a distance of 10 mm perpendicular to the treated surface. The specimens were cleaned with distilled water for 60 s and then dried with oil-free compressed air

Cementation procedures:

The dual cure resin cement Rylex U200 (Rylex U200, 3M, Germany) was applied with plastic instrument on the prepared surface of teeth (**Figure 25):** Then each post-core and endocrown was bonded to its corresponding tooth with finger pressure, then light activated at each surface for 20 seconds excess cement was removed immediately with a cotton pellet.

Artificial ageing programme:

cemented Endocrown and Post-Core for both groups I & II, were stored in distilled water at 37°Cfor one week**,** then received Thermocycling, (7000 cycles, equivalent totwoyear)[66], (mechatronicthermocycler the -1100 German). The cycle consists of a first step of 30 sec dwell time under a hot temperature water bath of 55°C, a second step of 6 sec transition timecorresponding to that of the room temperature25°C,a third step of 30 seconds dwell time under a cold temperature water bath of 5°C.

Fracture resistance:

All samples were individually mounted on a computer controlled materials testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) with a loadcell of 5 kN and data were recorded using computer software (Instron® Bluehill Lite Software)

Statistically analysis.

All data will be collected and statistically analyzed.

III. Results

Statistically significant difference was detected between PEEK Post-core with higher mean value than among PEEK endocrown (1863.24 & 1031.0, respectively).

	PEEK		**test of significance**
	Endocrown	Post-core	
Max Load (N) Mean ± SD	1031.0 ± 209.72	1863.24 ± 340.1	t=6.58 p<0.001*

IV. Discussion

Regarding to the design this result demonstrated that CAD-CAM post-core with PEEK materials gives the higher mean value than endocrown design. This result in agreement with **Al-shibri and Elguindy (2017)**[6]that was found that post-core with 2mm ferrule supported CAD crown recorded a statistically significant higher mean value fracture load than endocrowns made of this probably due to smaller adhesion area of endocrown compared to post-core which has more contact area for adhesion between post and 2 mm ferrule that support crown.

On other hands, **Guo et al (2016)**[7] noted that the endocrown doesn't show a higher mean fracture resistance value than conventional crown with post-core in mandibular premolars. These might be the reasons that the post inserted into the root canal connects the crown and root as a whole, and the post enhances the retention of the restoration.

Borzangy et al (2019)[8] showed the group of CAD-CAM polymer-infiltrated ceramic post-core recorded significantly higher resistance to fracture values. The resistance to fracture of wide root canals can be enhanced by using one-piece CAM-CAM post and core as an alternative to the use of either glass fiber post, relined with composite resin increasing the thickness of luting cement.

This result was opposed with **Lin et al (2009)**[9]who observed the favorable performance of endocrown restorations in premolars over conventional crown by using the finite element method and **Chang et al (2013)**[10] they found that the endocrown and conventional crown with post and core restorations for endodontically treated premolars did not significantly differ from each other. They explained that the endocrown restorations recorded comparable stress values because endocrown include both the crown and core as a single unit which decrease the effect of multiple interfaces that found in conventional crown. As well, thickening of the ceramic occlusal portion compared to the conventional crown.

Other study was opposed with our results as showed with **Enass et al (2017)**[11] who reported that no statistically significant difference in failure load among the four tested subgroups. Endocrowns recorded statistically significant mean higher fracture load values compared to post retained crowns. They concluded

thatlithium disilicate based endocrown restorations increase the fracture resistance of endodontically treated molars compared to conventional crowns associated with glass fiber posts and resin composite filling cores.

The present study was an in vitro investigation that could not fully replicate the oral conditions which was considered a limitation of this study. Additionally, the specimens were tested under a static loading condition, using PEEK materials.

V. Conclusion

Within the limitations of this in vitro study, it was concluded that:

1-All fracture resistance loads obtained were far beyond the maximum masticatory forces, which can withstand the maximum intra oral masticatory forces in the mandibular premolar regions.

2-Under the conditions of this study, fracture resistance load obtained in different test groups restored by PEEK Post-core treated mandibular premolar demonstrated significant greater failure resistance than Endocrown.

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