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EVALUATION OF THE INTERNAL FIT OF PRESSABLE VERSUS CAD/CAM PEEK POST AND CORE USING SCANNING ELECTRON MICROSCOPE: AN IN VITRO STUDY

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ABSTRACT

Aim: The study was conducted to evaluate the internal fit and marginal adaptation of custom-made Pressable compared to CAD/CAM PEEK post and core at three levels.

Methodology: Twenty-eight extracted maxillary central incisors were prepared for custom post and cores. Acrylic resin patterns were fabricated and divided into two groups: CAD/CAM group: The resin patterns were directly scanned and milled from modified PEEK blocks and Press group: Patterns were pressed with PEEK granules. The cement thickness was measured at four standardized points and the vertical marginal discrepancy was measured at twelve points using scanning electron microscope. One Way-ANOVA and Tukey`s post hoc test were performed to compare between the sections of each group; while Independent T-test was performed to compare between the two groups at different sections.

Results: Regarding CAD/CAM group, the mean cement thickness was the highest in the coronal section (85.57±17.81) followed by the middle (72.87±18.57) then the apical (45.92±18.73). While for Press group, the middle section showed the highest mean cement thickness (50.99±15.98), followed by the coronal section (39.70±18.16), the apical section (21.37±4.30). Comparing the two groups, CAD/CAM group had a significantly higher internal gap in all sections (P=0.0001). Among cores marginal adaptation, no significant difference in means of all surfaces was revealed between the CAD/CAM (98.83±13.90) and press (95.08±13.91) groups (P=0.54)

Conclusion: Within the limitations of this study, pressed PEEK post and cores achieved superior internal fit compared to CAD/CAM. Neither CAD/CAM nor pressing technique influenced the marginal adaptation of PEEK cores and both were within the clinical acceptance range.

KEYWORDS: CAD/CAM, heat pressing, post and cores, internal fit, marginal adaptation, PEEK, SEM.

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INTRODUCTION

The longevity of endodontically treated teeth has been greatly enhanced by continuing developments made in endodontic and restorative procedures. Most probably teeth submitted to endodontic treatment have a considerable amount of loss and destruction that may lead to the need for post and core replacement, in order to retain the final restoration. Innovative metal-free post systems are continuously being introduced in the market to achieve the goal toward more esthetic dentistry. A variety of esthetic materials are now available to satisfy the different case situations that can be either prefabricated of custom made.

Proper internal fit of the post systems inside the canals greatly affects their long-term prognosis. Poorly adapted posts exhibit non uniform thick cement layer that consequently will affect the retentive and mechanical properties of the restored tooth. Thereby, custom made post and cores have been preferable over prefabricated posts in some specific clinical situations, in order to achieve higher internal adaptation. [(1)]

Different technological advances in fabrication methods of restorations have been introduced over the past years. Rapid evolution of CAD/CAM technology (Computer Aided Design, Computer Aided Manufacture) in dentistry has exhibited a substantial impact over the past 25 years especially in the fields of prosthodontics. The integration of this technology system with advances in biomaterials was developed to solve several challenges. One of the challenges was to fabricate restorations with superior strength and to make more precise accurate restorations in a faster and easier way. Another technique being also broadly used is the pressing technique, which has its advantages and outstanding outcomes. [(2)]

Among innovative metal free restorations that has been introduced in the dental fixed prosthodontics field is Polyetheretherketone (PEEK). PEEK belongs to the Poly Acryl Ether Ketones (PAEK) family group, best-known as a high-performance polymer family. This material gained much attraction because of its acceptable fracture resistance, shock-absorbing ability, and proper stress distribution. Accordingly, PEEK applications have extended into several dental branches such as using it as intraradicular post and core that some studies claimed that it will take a considerable place as a routine in the future. PEEK applications have extended into several dental branches such as using it as intraradicular post and core that some studies claimed that it will take a considerable place as a routine in the future. [(3)]

Studies on the evaluation of the internal fit of custom made PEEK post and core is deficient despite the predictable promising outcome that can be provided by using this material specially that it can be constructed by either CAD / CAM or Pressing techniques. Accordingly, the present study was carried out to assess the marginal adaptation and internal fit of custom-made PEEK post and core using both techniques CAD / CAM and pressing utilizing scanning electron microscope. The null hypothesis tested was that there is no significant difference in the marginal and internal adaptation of CAD / CAM and pressable custom made PEEK posts and cores.

MATERIALS AND METHODS

All the experimental teeth used in the present in vitro study were collected from the Department of Oral and Maxillofacial Surgery of the institution, extracted due to periodontal reasons. A total of 28 maxillary central incisors were selected for this study that had similar average length dimension of 23-24 mm and canal configuration based on clinical and radiographic assessment. After thorough cleaning, the anatomic crowns of the teeth were sectioned parallel to cement-enamel junction (CEJ) and perpendicular to the long axis using a diamond rotary cutting instrument leaving 2 mm ferrule coronal to CEJ proximally. [4]

Endodontic treatment

Root canals preparation was performed using ProTaper gold rotary instrument system (Dentsply Maillefer, Switzerland) sequentially until F3 apical file. Root canals were irrigated continuously with 5 ml 2.5% Sodium Hypochlorite (NaOCl) in between each file and another. After instrumentation of the canals has been finished, they were rinsed with 0.9% normal saline and properly dried with absorbent paper points. Afterwards, obturation was performed with gutta-percha points and a resin-based sealer (ADSEAL, META Biomed CO., Korea) by cold lateral condensation technique. The samples were kept for 1 week at 37°C in an environment of 100% humidity to allow complete setting of the sealer.

Post space preparation

Each tooth was embedded centrally in a vertical dimension in an epoxy resin (Kemapoxy 150, CMB; Giza, Egypt) block with standardized dimension (Diameter: 14mm* Height: 27mm) utilizing a surveyor (Bredent BF2, GmbH & Co.KG, Germany). Later, post space preparation was done using milling machine hand-piece (Bredent BF2, GmbH & Co.KG, Germany) with speed 30,000 rpm and gutta-percha was removed from the canal by Gates Glidden drills sizes 2 & 3 (Dentsply-Maillefer, Switzerland) , then with peso reamer size 3 (Dentsply-Maillefer, Switzerland). A stopper from an endodontic file was attached to the gates glidden and the working length was set from a reference point of the most coronal core margin labially and standardized to 12 mm for all teeth leaving 3-4 mm of filling material at the apical third. Radiographs (70 kV and 0.08 s) of all teeth were taken to ensure proper removal of gutta-percha and absence of any undercuts.

The coronal portion of all teeth was prepared performing a deep chamfer finish line of 1 mm thickness all around using tapered stone with round end (ökodent Preußer OHG, Germany) and maintained 1 mm coronal to the acrylic resin block labially.

Acrylic resin patterns fabrication

Post and core pattern for each specimen was fabricated with autopolymerizing acrylic resin (Reliance Dental Manufacturing LLC, US). After lubricating the post space with a separating medium (MULTI-SEP Separating Medium; GC America), the powder and liquid monomer were mixed in a glass dappen dish according to manufacturer's instruction, and then added to a plastic post (Reliance Dental Manufacturing LLC, US) specialized for post and core resin patterns, which was fitted into the post space until complete polymerization. Once the post pattern was reached the predetermined standardized length, the core was built by adding additional acrylic resin using a brush until complete build-up and adaptation to the margin. Afterwards, core was finished using a diamond rotary cutting instrument (ökodent Preußer OHG, Germany) maintaining an equal core length of 4 mm.

All the 28 samples were divided randomly into two groups each containing 14 samples (n=14):

Group I: CAD / CAM PEEK post and cores

Group II: Press PEEK post and cores

Construction of PEEK post by CAD/CAM technique

The fourteen acrylic resin post patterns that were randomly selected for group I (CAD / CAM PEEK posts) have been prepared to be scanned and milled. The acrylic resin pattern was sprayed with contrast scanning spray (Renfert, Germany) and then it was attached by its core from the incisal edge to the extraoral scanner (DS Mizar, Italy) tray using sticky wax to stabilize it and make it accessible for scanning. Afterwards, the scanning process was carried out automatically by radiating the light and moving the shifting tray with the resin pattern fixed on it. Multiple camera screening positions were acquired to complete the full 3D scan of the pattern. Once the scanning was completed, designing and settings were adjusted on specialized CAD software (DScan 5 software, egsolutions, Italy). Finally, Standard Transformation Language (STL) file was saved and transferred to the milling machine. SHERA eco-mill 5X milling unit (SHERA, Germany) was used to mill the custom-made post and core from BioHPP blank (Bredent, UK) using dry milling technique and three burs sizes which were 2mm, 1mm and 0.6mm.

Construction of PEEK post by pressing technique

The rest of acrylic resin patterns (n=14) were prepared and pressed with BioHPP granulates (Bredent, UK) following manufacturer's instruction. A plastic sprue (Master Dental Laboratory Waxes & Supplies LLC., USA) was fabricated and attached to the coronal part of the resin pattern core with 45° and to the mold plate. Then, the mold plate was joined with the silicon ring ((Bredent, UK)) size 3 to be prepared for the investing. This silicon ring was specially manufactured to suit the mold system of the pressing unit used with BioHPP granulate and it was grooved inside that exhibits enlarged surface for fast moisture emission during pre-heating step.

A special phosphate-bonded investment material (Brevest investment material for 2 press, bredent; Germany) was then mixed according to manufacturer instruction with the ratio of 210 g powder and 53 ml of bresol liquid. The mixing was done under vacuum for 90 seconds and then poured into the mold embedding the post and core resin pattern.

The mold was pre-heated at 850°C for 60 minutes in the oven (IBEX dental technologies, USA) to control expansion. The melting procedure was held. Then, at a temperature of 400°C the mold was filled with the BioHPP granules for 20 min to be melted down. Press plunger was then inserted and the casting ring mold with the filled BioHPP granules was transferred to a special vacuum-pressing device (for 2 press; Bredent, Germany) and pressed at a pressure of 2.3 bar. BioHPP material was flown into the ring, and the whole procedure was completed fully automatically within 35 min when a blue LED light illuminated. The mold was placed in a water bath for a short time to make devesting much easier and free of dust. After the post and core was devested, the fine investment material residues were removed using a fine blasting device (Henry Schein dental, US) with aluminum oxide with 105 µm (Henry Schein dental, US) at a pressure of 2 bar according to manufacturer's instruction.

All the final post and cores were evaluated and checked in their corresponding teeth without any internal adjustment. Accuracy of posts was assessed and measured to check them with the predetermined standardized length. Also, marginal adaptation of the cores was evaluated initially by sharp explorer and magnifying loupes (Dr Kim, Korea) with 3.5X magnification power.

Post and cores cementation

All post and cores were cemented according to BioHPP manufacturer's instruction. Sandblasting with 110 μm aluminium oxides (Bredent, UK) at 2 bar blasting pressure was applied. Then, conditioning with light-hardened PMMA & Composite Primer "visio.link" (Bredent, UK) was done and polymerized within a light polymerization device (Woodpecker, China) for 90 sec. Calibra universal resin cement (Dentsply Sirona, USA) was applied and a specialized custom -made cementation assembly device with static loading was used to apply a standardized weight of 5 kg for 2 min to stabilize them.

Samples sectioning and preparation for microscopic assessment

Roots of all samples were sectioned horizontally perpendicular to their long axes into 3 sections (cervical, middle and apical) using Isomet (Buehler, USA) with a diamond blade disk (Buehler, USA) at low speed under water coolant, in order to obtain sections of 2 mm thickness. Each root was sectioned starting with the cervical slice at 1mm below the cemento-enamel junction labially, and then the middle and apical sections were taken with 2 mm thickness each. The exact thickness of the post segments in each slice was measured using a digital caliper.

Assessment with Scanning Electron Microscope (SEM)

After samples preparation, the resin cement thickness between the PEEK post and the canal wall of each slice was measured using scanning electron microscope (EDX; Inspect S, FEI, Netherlands) at different magnifications (x 150, x 400, x 800 magnifications). This was recorded using specialized xT SEM microscope control software (FEI xT Quanta, Netherlands) by placing two bisecting lines passing by the center of canal for each transverse cross section. Those bisecting lines intersect the cement layer at four standardized endpoints (A, B, C, D) at the middle of labial, palatal, mesial and distal surfaces for all slices at which the cement thickness was measured (Figure 1). The mean of the four points was calculated for each slice (coronal, middle and apical) of each root.

The vertical marginal discrepancy was assessed by measuring the cement thickness at the vertical distance between the core margin and the margin of the tooth at standardized points at mid of labial, lingual, mesial and distal surfaces. The measurements were performed using the scanning electron microscope with 200x magnifications at 12 selected points for each core, three points for each surface, one exactly at the middle and two other points 0.5 mm apart. Afterwards, the mean of three points of each surface was calculated for the statistical analysis.

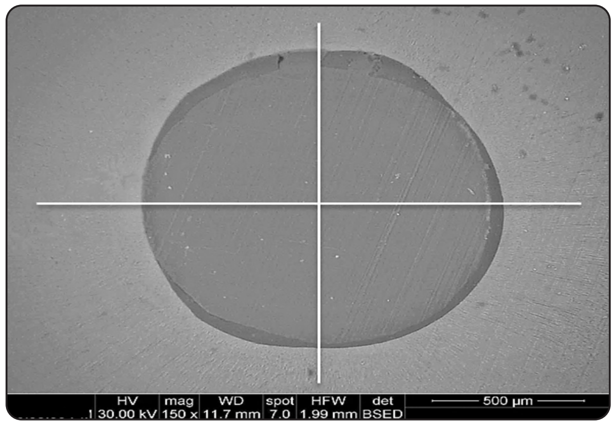

Fig. (1): Section under microscope 150x revealing the four measuring points

Statistical analysis

Statistical analysis was performed using SPSS 20®1, Graph Pad Prism®2 and Microsoft Excel 20163. Data were represented as mean and standard deviation and significant level was set at P value <0.05. Comparison between the two groups at different sections was performed by the Independent T-test, while comparison between three sections was performed by One Way Analysis of Variance ANOVA followed by Tukey`s post hoc test.

RESULTS

Data were summarized as mean ± SE (standard error of the mean). Regarding internal gap between different sections, in both group I (CAD/CAM group) and group II (Press group), the coronal and middle sections had significantly higher internal gap than the apical section (Figure 2). While revealed insignificant difference in means with the same superscript letters as P>0.05 between coronal and middle sections (Tables 1, 2). Comparing between the two groups using Independent t-test, it was revealed that group I was significantly higher in internal gap than group II (P<0.05) in coronal, middle and apical sections (Table 3)

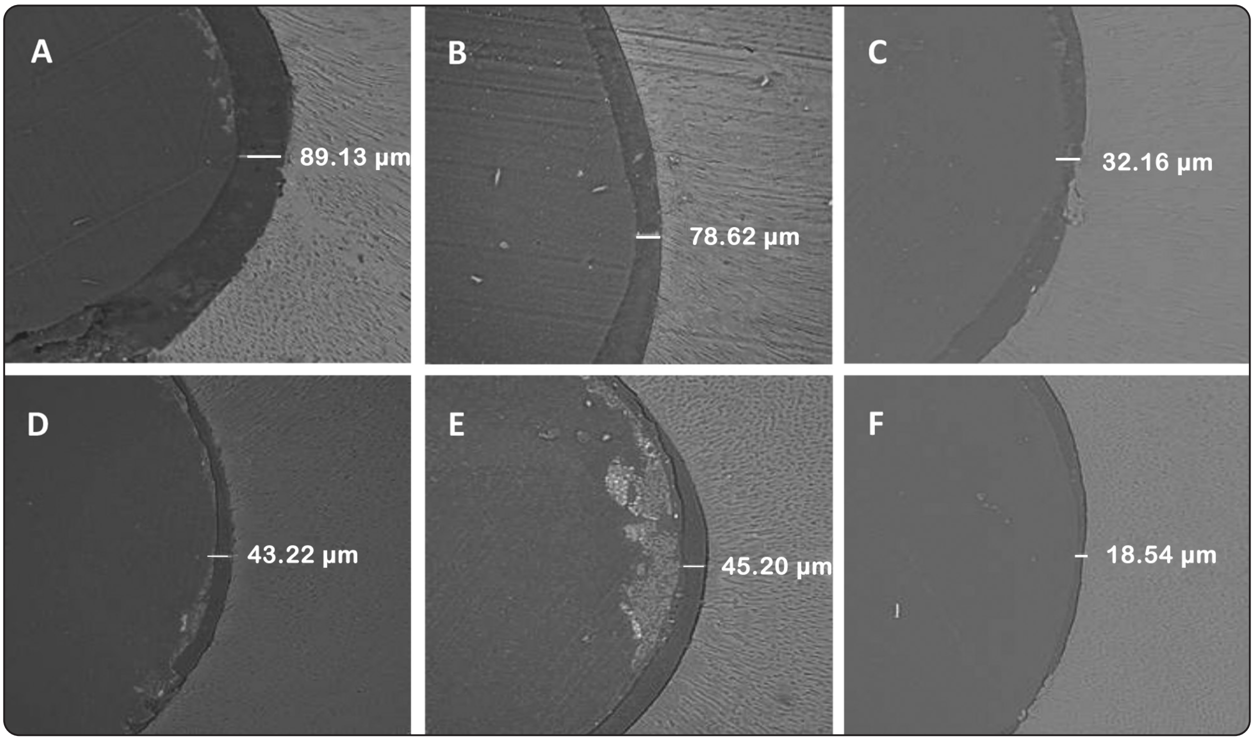

Fig. (2): SEM images showing cement thickness across the coronal, middle and apical sections for both groups at 400x magnification: (A, B &C): CAD/CAM group, (D, E &F): Press group

TABLE (1): Comparison between different sections in group I regarding internal gap in mm.

	Group I (CAD/CAM)		**P value**
	M	SD	
Coronal	85.57 [a]	17.81	
Middle	72.87 [a]	18.57	0.001*
Apical	45.92 [b]	18.73	
Total	68.12	18.37	

M: mean. ***SD: standard deviation.***

****significant difference.***

Means with different superscript letters are significantly different.

Mean with the same superscript letters are insignificantly different.

TABLE (2): Comparison between different sections in group II regarding internal gap in mm.

	Group II (Press)		**P value**
	M	**SD**	
Coronal	39.70 [a]	18.16	
Middle	50.99 [a]	15.98	0.001*
Apical	21.37 [b]	4.30	
Total	37.35	12.81	

M: mean. ***SD: standard deviation.***

****significant difference.***

Means with different superscript letters are significantly different.

Mean with the same superscript letters are insignificantly different.

TABLE (3): Comparison between group I & II regarding internal gap in coronal, middle and apical sections in mm.

	Group I		Group II		P -value
	M	SD	M	SD	
Coronal	85.57	17.81	39.70	18.16	0.0001*
Middle	72.87	18.57	50.99	15.98	0.0016*
Apical	45.92	18.73	21.38	4.30	0.0001*
Total	68.12	18.37	37.35	12.81	0.0001*

M: mean. SD: standard deviation. *significant difference.

Concerning marginal adaptation measurements of cores, comparison between two groups was performed using Independent t-test which shown that there was insignificant difference (P>0.05) between them in all surfaces as presented in table (4)

TABLE (4): Comparison between both groups regarding marginal gap in mm:

	Group I		**Group II**		**P value**
	M	**SD**	**M**	**S**	
Labial	109.32	20.23	105.49	13.69	0.53 ns
Lingual	98.29	10.89	104.67	20.16	0.32 ns
Mesial	99.47	18.01	86.93	16.14	0.053ns
Distal	88.22	12.38	83.21	10.65	0.24 ns
Total	98.83	13.90	95.08	13.91	0.54 ns

M: mean. SD: standard deviation. *significant difference.

DISCUSSION

Over the years, the use of customized post and cores for the restoration of endodontically treated teeth has been well documented, owing to the proper adaptation and less cement thickness between the post and canal walls of different configurations rather than using prefabricated posts. [5] Cement thickness affects polymerization shrinkage, voids formation, stress distribution and bond strength. Thereby the more adapted the post to the canal, the more pressure during cementation and the higher the bonding area between post/cement assembly and dentin. [6] Additionally, active post fitting with nonhomogeneous cement thickness can exert off-axis and excessive stresses on the tooth leading to high incidence of root fractures. [7]

Increased patient's demands to esthetic dental appearance in clinical practice led to the evolution of recent esthetic materials into the market throughout the years. The growing interest in tooth colored high performance polymers resulted in its widespread usage in several applications in the dental field. Polyether ether ketone (PEEK) has been introduced as an esthetic, rigid, semi-crystalline polymer with great thermal stability to be used efficiently in thinner thicknesses compared to ceramics. Modified PEEK containing 20% ceramic fillers which is known as BioHPP has proved to be used in prosthodontics as it has improved mechanical properties and biocompatibility. One of the applications of modified PEEK in prosthodontics was custom-fabricated post and cores that can be constructed either by CAD/CAM technology or pressing technique. [8, 9]

It was reported by **Lee and his co-workers in 2017** [10] that using PEEK material as an intraradicular post and core showed high fracture resistance compared to fiber glass and metal posts. Moreover, incidence of root fracture with PEEK posts proved to be the least during the biomechanical evaluation of a 3D finite element analysis**.** PEEK posts have exerted decreased stresses on the periodontal ligaments and the cortical bone with better distribution compared to glass fiber posts with metal-ceramic crowns [11]. In addition, PEEK material is a ductile and soft material that had a high adaptability property and convenient marginal fit. As a core material, PEEK polymer was also proved to be one of the successful materials to be used as the other gold standards. [12]

Therefore, the aim of this study was to assess the impact of technique of fabrication CAD/CAM and pressing technique on the internal fit of custom made PEEK posts and marginal adaptation of cores. Based on literature, the construction techniques had an effect on the adaptation of fixed restorations regardless of the material used. **Makky et al. in 2020** [19] clarified that the manufacturing technique had a significant influence on the marginal and internal fit of CAD/CAM versus pressable PEEK and zirconia copings.

However, studies on the use of PEEK material as post and core and the effect of different fabrication techniques on its marginal and internal fit are lacking despite its promising place in post-core treatment sector. As a consequence, the current study evaluated the marginal adaptation and internal fit of custom made PEEK post and cores fabricated by two different techniques.

Maxillary central incisor teeth with comparable roots dimension and canal configuration were used to simulate clinical condition. That is because the majority of them had a single straight canal configuration and they are more susceptible to trauma and fracture that increase their need for endodontic treatment and restoration. [13, 14]

A vertical holding device was used to fix each root in a standardized epoxy resin mold to ensure insertion of the root in a typical vertical position before post space preparation. This is also to be certain that sectioning of all roots into three slices by the Isomet was done exactly perpendicular to the long axis of the root and had no erroneous effect on cement thickness measurements. [15]

While drilling post spaces, the handpiece of a milling machine was used to ensure parallelism between the post preparation and the external wall of the resin block and to ensure no undercuts occurrence during preparation. [15]

Post and core acrylic resin patterns were directly fabricated inside the canals following manufacturer's recommendation of the material for both groups as this technique was advocated for single canal teeth. Auto-polymerizing resin pattern material provides proper rigidity, handling and can be burned out at the same temperature as wax leaving no residue after burnout, in order not to influence final post fitting.

Moreover, the use of acrylic resin can overcome the technique sensitivity of the indirect method that requires greater number of intermediate steps, which are mostly outside dentist control. However, like other resin materials, it has a limitation of polymerization shrinkage that was controlled first by incremental build-up of the material until complete polymerization and proper fitting of the resin posts in the canals. Secondly, the working time until the scanning procedure was done for the CAD/CAM group was standardized with the same time elapsed for the burning-out and pressing for the second group which was within an hour after resin patterns fabrication for the least shrinkage percentage. Nevertheless, the same material properties and condition of the patterns construction were standardized for both groups for not affecting the final results and not intervening with other material variables. [16, 17]

The resin patterns were scanned with extraoral scanner after spraying with an even light layer of scan spray to enhance the precision and maximum performance in the acquisition of 3D data by creating a uniformly reflective surface. [18] The milling machine used was 5-axis machine for better accuracy as it permits a more efficient milling of small angles and steep walls from different directions. [19]

The heat pressing procedure steps for group II were standardized and done according to manufacturer's instruction to ensure accuracy of the specimens as it is a sensitive technique that can affect the overall quality and properties of the material.

A specially designed cementation device with a constant load was used during the cementation procedure of all specimens to standardize the pressure load and ensure proper seating until complete setting of the cement. [19]

Different methods have been used to assess the internal adaptation of post and cores. Nevertheless, opinions still differ as to which is the most suitable method. One of these methods is the silicone replica technique, it is too difficult to preserve the silicone impression layer in this technique during post removal because of the smaller diameter of the post and the larger height compared to the crown. In the present study, the cross-sectional with direct measurement technique was used as it was adopted by many researchers as an accurate method for evaluating internal adaptation of posts. There are only a few simple steps in this method to directly measure the cement layer thickness with the least susceptible errors. Additionally, all measurements were made by the same investigator for standardization. [20]

Regarding the results of the current study, the null hypothesis that there will be no significant difference between the internal fit of CAD/CAM and pressable PEEK custom made post and cores was rejected. The internal fit of pressed post and cores was found to be significantly higher than the CAD/CAM group in the three horizontal sections (coronal, middle and apical).

Concerning group I (CAD/CAM group), the mean cement thickness was the highest in the coronal section (85.57mm±17.81) followed by the middle (72.87mm±18.57) then the apical (45.92mm±18.73). It was revealed a significant difference in means between coronal & apical – middle & apical sections, while no significant difference was found between the coronal and middle sections.

However, the high mean cement thickness in the coronal section of the CAD/CAM group and the significant difference could be due to the diameter of the milling tool that sometimes exceed the radius of the internal angle in this area leading to overmilling. In addition, the CAD software can trim part of the post in any area that has interpreted as undercut for the best fit. Furthermore, the round-ended milling burs used for fabricating CAD-CAM post and cores cannot accurately reproduce sharp angles at the junction between core and post, thus; clinicians must prepare rounded internal angles to avoid cervical misfits. [21,22] Accordingly, the reason for this result could have contributed to software trimming that is related to the anatomical configuration of the canal. [14]

On the other hand, regarding group II (Pressed group), the mean cement thickness was the highest in the middle section (50.99mm±15.98), followed by the coronal section (39.70mm±18.16), the apical section (21.37mm±4.30). Consequently, a significant difference in means was also found between coronal & apical – middle & apical sections, while no significant difference between the coronal and middle sections.

The significance difference and inhomogeneous variations between the three cross section levels of the pressed posts could be caused by nonuniform thermal and setting expansion of the used phosphate bonded investment material; resulting in instability of the pressing technique. It was reported that phosphate bonded investment material produce inhomogeneous setting expansion in a horizontal direction, which may lead to some distortion of the pattern and instability of the casting. [20]

Comparing the mean cement layer thickness of the two groups, it was found that the CAD/CAM group had significantly higher results in the three cross sections than the pressed group. Thus, according to the results of this study; heat-pressed PEEK based posts showed superior internal fit than the CAD/CAM technique.

In the current study, the results of the internal fit of PEEK post fabricated by both CAD/CAM and press techniques in this study were (68.12mm±18.37) and (37.35mm±12.81), respectively, are within the cement thickness ranging from 100 to 300 mm that has been reported to provide adequate bond strength between post-and cores and the remaining tooth structure. Moreover, gaps of up to 245 mm have been reported to be clinically acceptable for indirect restorations and associated complications (plaque accumulation, secondary caries, and luting cement exposure/dissolution) are less likely with post-and-cores. (22)

The significant difference between the internal fit of the two groups might be contributed to the highly sensitive many steps of CAD/CAM technology workflow and the potentiality of lab-induced errors. (22)

During the scanning procedure, the presence of small irregularities on the scanned surface may affect the accuracy of the entire data acquisition procedure. There is a possibility that any irregularities on the resin patterns were "smoothed out" by the CAD software to facilitate post fabrication. (23)

Additionally, heat pressing technique is a process in which temperature and pressure are applied simultaneously in order to melt ingot and press the material into the mold, resulting in the exact configuration of the restoration that lead to better internal adaptation. (24)

The results of internal fit of this study was with agreement with **Jafarian et al. in 2020** (7) who found out that conventional cast posts had better internal adaptation than milled post and cores constructed by a fully digital system in both oval and round canals. Also, this result was with alignment with the study conducted by **Tsintsadze et al. in 2018** (18) who revealed that the cement layer thickness around CAD/CAM fabricated fiber posts was significantly higher than custom cast posts.

Regarding the same material used in the current study, the result was similar to the result of **Makky et al. (2020)** (19) study who reported that PEEK Press copings had showed better internal fit than PEEK CAD group by three dimensional analysis using a triple scan protocol. However, they found no significant difference concerning the marginal adaptation of both groups.

Moreover, the results of internal fit was with agreement with **Martin et al. in 2019** (25) who reported that PEEK Press post and core had better internal adaptation than PEEK CAD/CAM when assessed by mCT.

On the other hand, the result of this study was opposed by **Liu et al. in 2019** (20) who found out that the CAD/CAM milled metal posts had lower cement layer thickness and better internal fit than cast post and cores in the coronal and apical cross sections, while no significant difference between them in the middle section. This could be related to the use of different materials during fabrication techniques which were silicone impression material for the CAD/CAM group and wax patterns for the cast group.

The result of the present study was opposed by **Perucelli in 2020** (22) who found no significant difference in the gap between posts and canal walls regarding the fabrication technique between the CAD/CAM composite resin post and cores constructed through part-digital workflow and cast post and cores in cervical and middle cross-sections. However, cement thickness was higher in the CAD/CAM group in the apical section. The insignificance difference that was found between the two groups could be due to the reduced sample size which was four samples in each group and the use of different assessment method for internal adaptation "microcomputed tomography" without cementation of posts with luting cement that is not simulating clinical situation.

Regarding the results of the marginal adaptation of cores, no significant difference in means of all surfaces was revealed between the CAD/CAM

(98.83mm±13.90) and press (95.08mm±13.91) groups. This result was consistent with **Makky et al. in 2020** [19] who found no statistical significant difference between the marginal adaptation of CAD/CAM and Press PEEK copings. While this result was opposed by **Attia & Shokry in 2020** [26] who reported that CAD/CAM PEEK copings showed significantly higher marginal adaptation than Press group.

However, results of vertical marginal discrepancy of both groups were under 100 μm which were within the clinically acceptable marginal gap range of 100-120 μm as stated in previous studies. [19, 27]

Meanwhile, the current study is an in vitro study which gives an idea about the clinical expectation of the newly introduced dental materials before their use in the clinical practice; however clinical trials should be the final determinant to the performance of these materials. Moreover, the addition of thermal cycling might have given more clinical simulation to the present study which is considered one of the limitations of this study.

CONCLUSIONS

Within the limitations of this in vitro study, the following conclusions can be withdrawn:

1. Since pressed PEEK custom-made post and cores revealed superior internal fit compared to CAD/CAM, it can be recommended as a promising treatment option if proper retention is lacking and in flared root canal morphologies.
2. The use of either CAD/CAM or pressing fabrication technique does not affect the marginal adaptation of PEEK cores, and both were within the clinical acceptance range.

RECOMMENDATIONS

1. Further studies on the evaluation of internal fit of CAD/CAM PEEK post and cores fabricated by the recent full-digital workflow.
2. Further investigations comparing the internal adaptation of PEEK post and cores with other esthetic post materials.
3. Clinical studies evaluating PEEK post and cores with long-term follow-up.

REFERENCES

1. Gomes, G. M., Monte-Alto, R. V., Santos, G. O., Fai, C. K., Loguercio, A. D., Gomes, O. M., Gomes, J. C., & Reis, A. (2016). Use of a direct anatomic post in a flared root canal: a three-year follow-up. Oper Dent, 41(1), E23–E28.
2. Zarina, R., Jaini, J., & Raj, R. S. (2017). Evolution of the software and hardware in cad/cam systems used in dentistry. Int. J. Clin. Prev. Dent., 4(4), 284-291.
3. Tekin, S., Cangül, S., Adıgüzel, Ö., & Değer, Y. (2018). Areas for use of peek material in dentistry: J. Int. Dent. Medical Res., 8(2), 84–92.
4. Rayyan, M. R., Aldossari, R. A., Alsadun, S. F., & Hijazy, F. R. (2016). Accuracy of cast posts fabricated by the direct and the indirect techniques. J Prosthet Dent, 116(3), 411–415.
5. Zsuzsanna, B. V., & Diana, C. (2016). Clinical evaluation of cement thickness around pre- fabricated vs. costume-fabricated posts. Eur. Sci. J., 12(27), 39.
6. Eid, R. Y., Koken, S., Baba, N. Z., Ounsi, H., Ferrari, M., & Salameh, Z. (2019). Effect of fabrication technique and thermal cycling on the bond strength of CAD/CAM milled custom fit anatomical post and cores: an in vitro study. J Prosthodont , 28(8), 898–905.
7. Jafarian, Z., Moharrami, M., Sahebi, M., & Alikhasi, M. (2020). Adaptation and retention of conventional and digitally fabricated posts and cores in round and oval-shaped canals. Int J Prosthodont, 33(1), 91–98.
8. Mishra, D.R., Shetty, D.V., D'Costa, D.V., & Shetty, D.K. (2017). Evolution of posts-from rigidity to flexibility. Int. J. Sci. Res., 6(5), 2671–2677.
9. Georgiev, J., Vlahova, A., Kissov, H., Aleksandrov, S., & Kazakova, R. (2018): Possible application of BIOHPP in prosthetic dentistry: a literature review: J of IMAB, 24(1), 1896–1898.
10. Lee, K., Shin, J., Kim, J., Kim, J., Lee, W., Shin, S., & Lee, J. (2017): Biomechanical evaluation of a tooth restored with high performance polymer PEKK post-core system :

a 3d finite element analysis. Biomed Res. Int., 2017(2), 1-9.

11. Tekin, S., Adıgüzel, Ö., & Cangül, S. (2018). An evaluation using micro-CT data of the stress formed in the crown and periodontal tissues from the use of peek post and peek crown: A 3D finite element analysis study: J. Int. Dent. Medical Res., 8(3), 144–150.
12. Bathala, L., Majeti, V., Rachuri, N., Singh, N., & Gedela, S. (2019): The role of polyether ether ketone (peek) in dentistry - A review: J Med Life, 12(1), 5–9.
13. Rezaei, M., Amirian Chaijan, K., & Tavanafar, S. (2015). Fracture resistance of upper central incisors restored with different posts and cores. Restor Dent Endod, 40(3), 229–235.
14. Muttlib, N., Azman, A., Seng, Y., Alawi, R., & Ariffin, Z. (2016). Intracanal adaptation of a fiber reinforced post system as compared to a cast post-and-core, ASCRO, 50(4), 329–336.
15. Amin, R. A., Mandour, M. H., & El-ghany. (2014): Fracture strength and nanoleakage of weakened roots reconstructed using relined glass fiber – reinforced dowels combined with a novel prefabricated core system. J Prosthodont, 23, 484–494.
16. Sabouhi, M., Nosouhian, S., Dakhilalian, M., Davoudi, A., & Mehrad, R. (2015). The effect of time and storage environment on dimensional changes of acrylic resin post patterns. Open Dent. J., 9, 87–90.
17. Fallah-tafti, A., Lotfi-kamran, S. M. H., Abrisham, S. M., Fallah-tafti, R., Amini, M., Reza, M., Meibodi, H., & Sadoughi, S. (2018): Acrylic resin post patterns J. dent. mater. tech..,7(1), 33–38.
18. Tsintsadze, N., Juloski, J., Carrabba, M., Goracci, C., Vichi, A., Grandini, S., & Ferrari, M. (2018). Effects of scanning technique on in vitro performance of CAD/CAM-fabricated fiber posts. J. Oral Sci., 60(2), 262–268.
19. Makky, M. R., Shokry, T. E., & Metwally, M. F.: (2020): Comparison of marginal and internal fit of copings fabricated from polyetheretherketone and zirconia : an in-vitro study. Al-Azhar J. Dent. Sci., 23(4), 355–362.
20. Liu, W., Qing, H., Pei, X., & Wang, J. (2019). Internal adaptation of cobalt-chromium posts fabricated by selective laser melting technology J Prosthet Dent., 121(3), 455–460.
21. Moustapha, G., AlShwaimi, E., Silwadi, M., Ounsi, H., Ferrari, M., & Salameh, Z. (2019). Marginal and internal fit of CAD/CAM fiber post and cores, Int. J. Comput. Dent., 22(1), 45–53.
22. Perucelli, F., Goulart da Costa, R., Machado de Souza, E., & Rached, R. N. (2020). Effect of half-digital workflows on the adaptation of customized CAD-CAM composite post-and-cores. J Prosthet Dent, S0022-3913(20)30463-7. Advance online publication.
23. Salaheldin, M., Sherif, A., Mohammed, A.,& Nossair, S. (2019). Comparison of accuracy of restorations generated through digital images of two extra oral scanners. Egypt Dent J , 65(3), 2921-2929.
24. Varvara, A.M., Burde, A.V., Gasparik, C., Mesaros, A.S., Varvara, E.B., Culic, B. & Dudea, D. (2018): Aesthetic characteristics of lithium disilicate ceramic : machinable versus pressed technique – A questionnaire - based study: University of medicine and pharmacy, Cluj-Napoca, Romania, 309–316.
25. Martin, L., , Mateus, R., ; Edgar, O., & Panagiotis, Z. (2019). 3D accuracy analysis between heat-pressed and CAD-CAM polyetheretherketone (PEEK) post and core restorations. [Abstract], ICP,195-196.
26. Attia, M. A., & Shokry, T. E. (2020): Effect of different fabrication techniques on the marginal precision of polyetheretherketone single-crown copings: J Prosthet Dent, 124(5), 565.e1-565.e7.
27. Son, K., Lee, S., Kang, S. H., Park, J., Lee, K. B., Jeon, M., & Yun, B. J. (2019). A comparison study of marginal and internal fit assessment methods for fixed dental prostheses, J. Clin. Med., 8(6), 785.