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EFFECT OF TWO DIFFERENT IMPRESSION TECHNIQUES ON FIT ACCURACY OF CAD/CAM POST AND CORE RESTORATIONS

Radwa S. Abd Elmonem[1]* *BDs* Mohammed W. Elkateb[2] *PhD,* Amir S. Azer[3] *PhD.*

ABSTRACT

INTRODUCTION: Endodontically treated teeth restoration is a challenging dental procedure. Restored teeth failure threshold is mainly related to posts to root canals adaptation.
OBJECTIVE: To examine the consequence of using two different intracanal impression techniques on the accuracy of fit of CAD/CAM hybrid ceramic post and core restorations.
MATERIALS AND METHODS: Twenty mandibular first premolars were chosen then endodontically treated and prepared for receiving post and core restorations. The specimens were randomized into two equal groups: CAD/CAM post and core restorations for group I were obtained by scanning the auto polymerizing acrylic resin pattern. For group II polyvinylsiloxane impressions of the post space were scanned. Post and core restorations were milled and cemented on their respective teeth. All of the 20 specimens were then sectioned longitudinally and the post and core adaptation were evaluated using the stereomicroscope.
RESULTS: With the impression scanning technique, the overall space that was made between the canal walls and posts ranged between 72.93 - 135.62 µm, with a mean value of 96.21 ± 18.44 µm, whereas with the acrylic pattern scanning technique, the space ranged between 105.57 - 126.91 µm, with a mean of 115.52 ± 7.51 µm.
CONCLUSIONS: For the manufacture of hybrid ceramic post and core restorations, the impression scanning technique achieved better fit and higher accuracy than the acrylic pattern scanning technique.
KEYWORDS: Post and core, Hybrid ceramic, Intracanal impression, CAD/CAM.
RUNNING TITLE: Impression techniques effect on post and core accuracy.

1 Bachelor of Dentistry, Conservative Dentistry Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
2 Professor of Fixed Prosthodontics, Conservative Dentistry Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.
3 Associate Professor of Fixed Prosthodontics, Conservative Dentistry Department, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.

* *Corresponding Author:*

E-mail: dr.radwashaker@gmail.com

INTRODUCTION

In dentistry, the broad use of ceramic materials is due to their biocompatible and chemically inert nature, their ability to reduce plaque accumulation, and resist abrasions, besides, a respectful compressive strength, superior esthetics, and color stability of these materials (1). Nowadays, continuous development of novel and variable ceramic materials, with multiple mechanical and aesthetic characteristics are achieved, in parallel with CAD/CAM development and improvements (2).
For CAD/CAM restorations, hybrid ceramic (Vita Enamic) was recently used. Vita Enamic is a polymer-infiltrated ceramic network material (PICN) that is consisted of a dominant porous feldspathic ceramic network (86wt %) and is insinuated with a copolymer (14wt %). Coldea et al. reported a higher tolerance of PICN materials than the frequently applied dental ceramics.
The advantages of ceramic and composite resin are combined in the PICN materials, have flexural strength and elastic modulus like tooth structure thus absorb stress, and reduce stiffness in comparison with ceramics, suggesting them to be considered restorative materials of high efficacy (3).
The degree to which the repair and supporting structures fit together is called adaptation. Poor posts adaptation may produce levers inside the root canal, increasing the susceptibility of the tooth is to fractured and will generate a marginal gap through which the existence of deficient cementation may result in micro leakage. When the leakage is

prolonged, this will separate the post from the root canal causing post-core systems failures. Marginal discoloration and fracture as well as secondary caries can all be caused by penetration of oral fluids, microbial toxins, and any ions in the interfacial area between the restoration and the tooth (4).

A 3-D model of the post and core can minimize dimensional variations in gypsum and the pattern materials like resin or wax when post and core is numerically organized and milled instead manual preparation of the pattern that means the fabrication process can be improved in terms of precision and time savings (5).

Several works mentioned the important relation between post systems adaptation and occlusal loading, bond strength, and fracture resistance. As a result, a proper impression technique could have a direct impact on the clinical survival rate of the final restorative therapy as it affects the post retention of the custom-made in a direct manner. An increase in the quality of impressions that can be used to improve post adaptation to the root canal is required (6).

Accordingly, this work purposed to compare the effect of two different intracanal impression techniques on the fit accuracy of CAD-CAM generated post and core restorations and milled from hybrid ceramic blocks, the null hypothesis is that different intracanal impression techniques have no effect on the accuracy of fit.

MATERIALS AND METHODS

1. Specimen preparation

Twenty sound, single rooted mandibular first premolars with nearly typical size and shape extracted for orthodontic causes were gathered from the oral surgery department of Alexandria University. Selection criteria include the absence of root caries, restorations, or previous endodontic treatment.

Removal of all pulp tissue was done, followed by cleaning and shaping of the canals using a manual Pro Taper system (Dentsply-Maillefer, Ballaigues, Switzerland). Then, via the lateral condensation technique, obturation of the root canal with gutta-percha points was performed. Storage of the root canal-filled teeth was at 37°C with 100% humidity for seven days to ensure a complete set of the sealer (2).

The anatomic crowns of the teeth were sectioned perpendicular to the long axis 2mm coronal to the CEJ, with a diamond disc (komet dental ,Lemgo, Germany) in order to attain standardized length of 14 mm.

2. Post space preparation

The post space preparation for all the groups was initiated with peeso reamer drills (Dentsply, Maillefer, Tulsa, OK, USA), then all the teeth were carefully set to a depth of 9 mm by the same calibration drill (special calibration drill, black unimetric 1.0 kit tapered post drills, Dentsply Maillefer, OK, USA) for final shaping of the post space keeping 4 to 5 mm for apical sealing (7).

All teeth were individually mounted vertically in self-curing acrylic resin (ACROSTONE Dental, Cairo, Egypt) blocks to a depth of 2 mm apical to the cementoenamel junction using a copper split mold (8).

3. Post space impression techniques and CAD/CAM hybrid ceramic post and core Fabrication

The twenty teeth were randomized into two equal groups (N=10) based on the used intracanal impression technique.

Group I: Post and core patterns were made from prefabricated plastic posts (Uniclip burnout plastic post, Maillefer, Dentsply, USA) relined with auto polymerizing acrylic resin (Duralay) (Reliance Dental Manufacturing, Worth, IL, USA). The post and core patterns were coated with an extra oral powder scan spray then scanned using an extra-oral scanner (inEos X5, DENTSPLY SIRONA, PA, USA), data were processed using the in-lab CAD 16.1 software then the post and core restorations were developed from the milling of VITA ENAMIC blocks (VITA Zahnfabrik, Bad Säckingen, Germany) with in-Lab MC X5 milling machine (DENTSPLY SIRONA, PA, USA).

Group II: Polyvinylsiloxane impression material (SwisstecHydroXtreme, Nicadent, Switzerland) was used to make the impression of the post space and the remaining coronal tooth structure. In this technique, a plastic post was put into the canal to provide additional support for the body impression material after it was administrated into the canal. A customized tray loaded with a heavy body was then seated. Scan spray (Engen, Germany) was applied on the impression prior to its scanning using an extra-oral scanner (inEos X5, DENTSPLY SIRONA, PA, USA) to create virtual 3D dies onto which the restorations would be designed using the in-lab CAD 16.1 software and then milled using in-Lab MC X5 milling machine (DENTSPLY SIRONA, PA, USA) (9).

4. Post and Core Cementation

The inner surfaces of the post and core restorations were etched with 9% hydrofluoric acid (iTena, Paris, France) for 60s and subsequent silanization (iTena, Paris, France) was performed using a micro-brush on both the post and the internal surface of the core for the post and core restorations then air-dried in accordance with the manufacturer's guidelines.

Then, post-core restorations were cemented to their respective teeth with dual-cure self-adhesive resin cement (Rely™ Unicem, 3M/ESPE , Seefeld, Germany) (**Figure 1**). The restorations were kept under the static load device (1kg) for 5 minutes resulting in a standardized homogeneous cement film thickness, exposed for 5 seconds to brief light

curing to eliminate the excess cement easily then exposed for 40 seconds to prolonged light curing to ensure total polymerization of the resin cement (10).

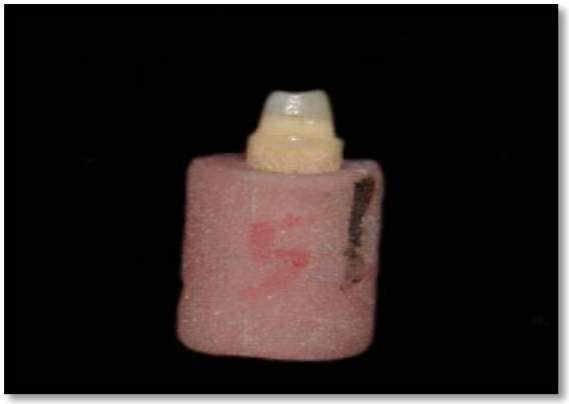

Figure (1): Cemented post and core restoration.

5. Microscopic Evaluation

The teeth were sectioned longitudinally using a diamond disc (Isomet; Buehler, USA) under water at a slow speed and marked at three points along the tooth length from the dentin-core interface to the apex on either side at 2 mm to get coronal area, 5mm to get middle area and 8mm to get apical area (**Figure 2**). The gap width between the post surface and the internal canal wall was evaluated by stereomicroscope (Olympus Corp, Tokyo, Japan) at ×70 magnifications (11).

Results were obtained by calculating the mean of the measurements taken at the previously marked areas (**Figure 3).**

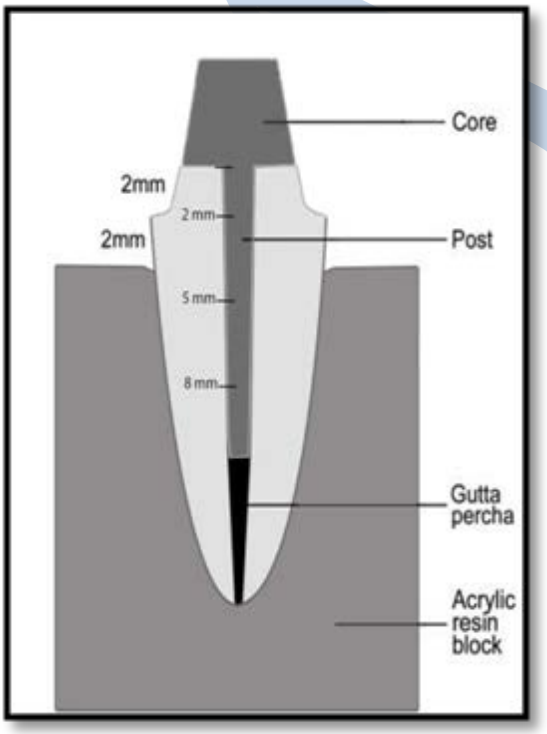

Figure (2): Diagram showing the levels of gap width measurement points for the internal fit of the post and core restoration evaluation.

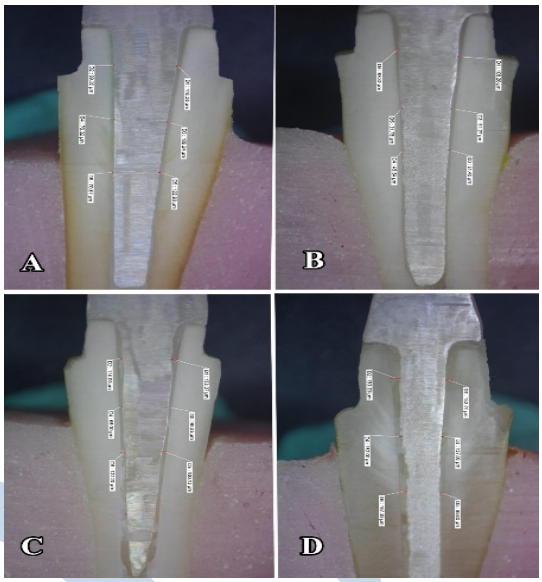

Figure (3): Gap width evaluation using stereomicroscopic magnification (×70) for polyvinylsiloxane impression scanning group in (a and b) and for Acrylic pattern scanning group in (c and d).

6. Statistical Analysis

Each root was treated as a statistical unit. Data from the different marked points were collected, tabulated and analyzed to give a single mean and standard deviation for each root. Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation ,median and Inter quitter range (IQR). Significance of the obtained results was judged at the 5% level.

Student t-test (tukey's post hoc test) and F-test (ANOVA) were performed to assess the effect of intracanal impression techniques on the accuracy of fit of CAD/CAM post and core restorations

RESULTS

This study compared the accuracy of fit of CAD/CAM generated post and core restorations, milled from hybrid ceramic blocks using two different intracanal impression techniques.

Results were obtained by calculating the mean of the measurements taken between the outer post surface and the edge of the internal canal wall at the marked points. Six measurements were obtained from each sample, three from each side at 2, 5 and 8 mm of the post on the length of the tooth from the

cement– enamel junction to the apex. Mean of measurements of the horizontal space surface area at 2, 5 and 8 mm of the post on the length of the tooth from the cement– enamel junction to the apex indicate the relative post fit at the coronal, the middle and the apical part of the post respectively.
The one-way ANOVA test showed a high statistically significant difference (P<0.001) among the different root canal sections in both groups. Gap width at the coronal root section showed the highest measurement followed by middle followed by apical root section. Table (1) shows Comparison of the different root canal sections as regard the gap width (µm) in each studied group.

Table (1): Comparison of the different root canal sections regarding the width of gap (µm) between the Duralay group and the Impression group.

	Coronal	Middle	Apical	ANOA test	p
Duralay (n =10)					
Min. – Max.	91.41 – 152.7	72.51 – 126.4	76.51 – 121.4	12.768*	<0.001*
Mean ± SD.	138.2 ± 17.81	105.3 ± 17.57	103.1 ± 16.87		
Median (IQR)	141.5 (137.3 – 150.6)	105.0 (98.63 – 121.6)	110.3 (87.01 – 117.7)		
Sig.	p1=0.001*, p2<0.001*, p3=0.958				
Impression group (n =10)					
Min. – Max.	86.49 – 144.1	57.59 – 138.4	42.93 – 127.0	7.657*	0.002*
Mean ± SD.	119.5 ± 20.55	88.02 ± 23.23	81.08 ± 26.15		
Median (IQR)	124.7 (103.8 – 135.6)	88.63 (69.57 – 95.57)	77.93 (65.18 – 96.80)		
Sig.	p1=0.015*,p2=0.003*,p3=0.787				

Pairwise comparison bet. the Duralay group and Impression group was conducted using Post Hoc Test (Tukey)
p: p value to compare between Coronal, Middle and Apical in all groups
p1: p value to compare between Coronal and Middle
p2: p value to compare between Coronal and Apical
p3: p value to compare between Middle and Apical
*: Statistically significant at $p \leq 0.05$

Tukey's post-hoc test presented a significant difference (P=0.05) between **Group I** (acrylic pattern scanning technique) and **Group II** (Polyvinylsiloxane impression scanning technique) at the coronal and apical root canal sections. On the contrary, the middle root canal section achieved no significant difference. **(Table 1) (Figure 4)**

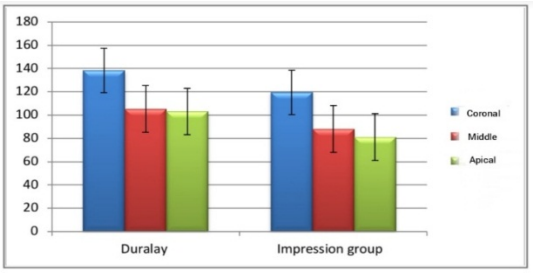

Figure (4): Mean of gap width in the acrylic pattern and polyvinylsiloxane impression scanning groups at the coronal, middle, and apical root canal sections.

Also, the mean gap width of both groups was estimated and statistically assessed using descriptive statistical analysis **(Table 2) (Figure 5)**. With the impression scanning technique, the overall space that was made between the canal walls and posts ranged between 72.93 - 135.62 µm, with a mean value of 96.21 ± 18.44 µm, whereas with the auto polymerizing acrylic resin pattern scanning technique, the space ranged between 105.57 - 126.91 µm, with a mean of 115.52 ± 7.51 µm. Using Tukey's post-hoc test, there was a statistically significant difference (P<0.001) between the results of either intracanal impression techniques. Polyvinylsiloxane impression scanning technique provided post and core restoration with a better fit and higher accuracy.

Table (2): Comparison of the values of the overall gap width (µm) of the Duralay group and the Impression group.

	Duralay (n =10)	Impression Group (n =10)	Student t-test	p
Average				
Min. – Max.	105.57 - 126.91	72.93 - 135.62	3.066*	0.007*
Mean ± SD.	115.52 ± 7.51	96.21 ± 18.44		
Median (IQR)	116.40 (110.1-122.5)	96.13 (81.5-100.9)		

SD: Standard deviation IQR: Inter Quartile Range
p: p value to compare between the Duralay group and the Impression group
*: Statistically significant at $p \leq 0.05$

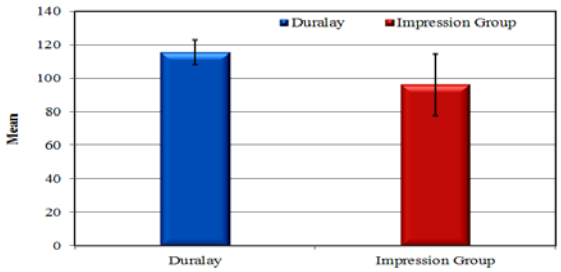

Figure (5): Mean of overall gap width values in the acrylic pattern and polyvinylsiloxane impression scanning groups.

DISCUSSION

This study was designed to compare the accuracy of fit of CAD/CAM generated post and core restorations, milled from hybrid ceramic blocks using two different intracanal impression techniques.

Vita Enamic hybrid ceramic blocks were used in this study to avoid the need for further crystallization firing after milling, based on a previous study that showed that using materials for CAD/CAM blocks that don't necessitate extra firing cycles shows superior marginal adaptation to those that need further steps in fabrication after milling (12).Another benefit of Vita Enamic material is the machinability of the material, it is a soft dual network material of ceramic and composite, so This material can be milled in a faster way and diminish the wear for the cutting burs (13).

Higher bond strength and micromechanical interlocking have been found when a post and core is properly adapted to the canal walls. Luting cement layer thickness between 100 and 300 µm was documented to offer acceptable bond strength between post and cores and the residual tooth structure (14).

Since earlier, post and core patterns have been fabricated using auto polymerizing acrylic resins. Their methyl methacrylate base polymerization shrinks, resulting in dimensional alteration (15). Mosharaf and Ghasemzadeh (16) assessed the self-cure acrylic resin dimensional changes in dissimilar storing circumstances. They recommended preserving the pattern in wet conditions if there is a delay of more than one hour.

Also, these results were demonstrated by Ghanbarzadeh J's study (17) which found a negative impact on acrylic resin patterns dimensional stability when the storage period is prolonged. They added that for 24 hours, 100% humidity at 25°C is considered the best storage condition. Also, Iglesias A et al. study showed equal or smaller gaps produced by the incremental pattern fabrication technique than the bulk technique (18).

As a result, factors such as pattern fabrication technique, storage period, and media that altered the dimensional stability of auto polymerizing acrylic resins may have contributed to the considerable disparities in gap width found in the acrylic pattern scanning group in the current study.

Falcão Spina et al. (9) and Lee JH. (19) claimed that using the polyvinylsiloxane impression allowed for faster and more accurate milled post and core restoration fabrication than using a traditional duralay pattern. They also stated that this technique made milling the post and core simple, thus reducing human error and chair time.

Sectioning and direct view using stereomicroscope has been used in this study for estimating the gap width between the post surface and the internal canal wall. The cross-sectioning approach reduces the danger of repositioning by allowing immediate evaluation of the internal fit and marginal gap in both vertical and horizontal planes under the microscope (20).

On the basis of the present work findings, the null hypothesis that the two different intracanal impression techniques would have no influence on the internal fit of CAD/CAM hybrid ceramic post and core restorations was rejected.

The generated CAD/CAM post and core restoration fabricated by the polyvinylsiloxane impression approach had the least gap width and attained higher adaptation in comparison with acrylic resin pattern technique. Yet, of both groups, the mean gap value ranged from 42.93 to 152.7 µm, which was in the clinically adequate range (100-300) µm.

Due to the importance of post fitting in post retention, our findings agreed with the results of Pitigoi-Aron et al (21), who stated better fit and accuracy of indirect approach using polyvinylsiloxane impression material than the direct technique with the acrylic resin pattern. However, the present work findings differed from that reported by Al-Omari and Zagibeh, and also Rayyan MR (22), who found that both direct and indirect techniques are comparable and have no effect on the cast post and core fit accuracy.

Hendi AR et al. (23) also examined the fit accuracy of the fabricated post and core restorations using three different techniques. The results revealed that the largest gap was made by scanning elastomeric impression material technique while the smallest was produced by the conventional acrylic pattern fabrication technique and the direct intraoral scanning technique produced an intermediate gap. These controversial findings could be resulted from using different post-fabrication techniques, measuring the accuracy of post fit via different methods, or variation in the number of measurements per specimen in these studies.

Even though CAD/CAM technology has advanced significantly, there may still be some clinical issues. The fitting accuracy of CAD/CAM restoration can be influenced by different factors, including the scanning protocol, software design, milling, and effects of shrinkage. Also, other possible causes of accuracy problems and dimensional errors are the procedure of application of optical contrasting powder, misalignment of the camera, the distance between the scanned surface and camera, and different orientations of imaging walls to the camera.

According to Reich et al. (24) scanning with finite resolution is an obstacle. Fit imperfections are caused by the existence of rounded angles or peaks during the scanning procedure. Another explanation for the difference in internal fit results among the

studied groups is proposed to be the result of the point clouds phenomenon during scanning of small areas (25).

For each restoration type and CAD-CAM system, adjustments to the setting of the cement size should be performed (16) As a result, for compensating the antireflective spray thickness and for ensuring the passive fit of the restoration, a cement space of 40 µm was set in the software. Also, the large scanning powder thickness in the deepest spaces of canals and corners may negatively affect the optical scans (26).

An important consideration for milling internal contours in the CAM process is that the milling instrument diameter and shape may reduce the machining accuracy and fit of the restorations (27).

It is necessary for clinicians to prepare rounded internal angles for CAD-CAM post-and-cores because round-ended milling burs cannot accurately reproduce sharp angles (16). Moreover, during the milling process, factors such as diamond rotary cutting instrument wear and water quality can have an impact on the quality of the restorations as a whole.

The use of the same CAD/CAM system, restorative material, and the spray used to digitize the specimens are the limitations of the present study. If different systems or materials had been used, the results might have been different.

CONCLUSIONS

On the basis of the reported findings and within this invitro study limitation, it could be concluded that:

- In all studied groups, the range of all observed gap values was clinically acceptable.
- The adaptability of CAD/CAM generated hybrid ceramic post and core restorations was influenced by the fabrication technique.
- The polyvinylsiloxane impression scanning technique for manufacturing hybrid ceramic post and core restorations displayed better fit and more accuracy than the acrylic pattern scanning technique.

CONFLICT OF INTEREST

There were no conflicts of interest revealed by the authors.

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