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EVALUATION OF AN EXPERIMENTAL SCREW-RETAINED RETRIEVABLE CROWN VERSUS CONVENTIONAL CROWN DESIGN

Mohammad M. Rayyan
Associate Professor, Department of Oral Rehabilitation Sciences, Faculty of Dentistry, Beirut Arab University, m.rayyan@bau.edu.lb

Ahmed Naguib M Hussien
Professor of Fixed Prosthodontics, Faculty of Dentistry, Cairo University and Future University, anaguib23@hotmail.com

Hanan A. Naguib
Professor of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Egypt - and King Abdulaziz University, hanannaguib@yahoo.com

Hiba A. Makarem
Graduate student, Faculty of Dentistry, Beirut Arab University, hiba.makarem@gmail.com

Post and core, Retrievability, Fracture resistance, and Microleakage

EVALUATION OF AN EXPERIMENTAL SCREW-RETAINED RETRIEVABLE CROWN VERSUS CONVENTIONAL CROWN DESIGN

Mohammad M Rayyan[1], Ahmed Naguib M Hussien[2], Hanan A Naguib[3], and Hiba A Makarem[4]
[1] Associate Professor of Prosthodontics, Faculty of Dentistry, Beirut Arab University, Lebanon
Email: m.rayyan@bau.edu.lb
[2] Professor of Fixed Prosthodontics, Faculty of Dentistry, Cairo University and Future University, Egypt
Email: anaguib23@hotmail.com
[3] Professor of Fixed Prosthodontics, Faculty of Dentistry, Cairo University, Egypt - and King Abdulaziz University, Saudi Arabia / Email: hanannaguib@yahoo.com
[4] Graduate student, Faculty of Dentistry, Beirut Arab University, Lebanon
Email: hiba.makarem@gmail.com

ABSTRACT: Statement of problem: Removing cemented crowns is usually a complicated procedure that may lead to irreversible damage to the tooth/crown and mostly necessitate remake of crown with added effort for both patient and clinician. Purpose: This in-vitro study evaluated an experimental two-component, screw-retained retrievable crown design in comparison to the conventional design. Materials and methods: A total of 120 extracted maxillary 2nd premolars received root canal treatment and were divided into two groups (n=60 each) according to the crown design they will receive. Gp CC received a threaded modified post, a composite core and a metal coping, while Gp RC received a two-component retrievable crown design. Fracture resistance was assessed by a 90 degrees vertical load to the center of the occlusal surface, using universal testing machine, under a constant crosshead speed of 0.5 mm/min until failure. Microleakage was assessed by placing specimens in methylene blue dye for 12 hours, sectioning the teeth longitudinally, and then examining the sectioned samples under stereomicroscope. Retrievability testing was conducted by 5 prosthodontists who attempted to uncover and unscrew the posts. Data were statistically evaluated using computer software (SPSS version 17; SPSS Inc.).

Results: No significant difference between the 2 designs tested regarding microleakage tests (P=.34) whereas the experimental design, was significantly more resistant to fracture and more retrievable than the conventional one (P>.5).

Conclusions: The proposed retrievable crown design showed promising results and may be considered as an option to substitute the conventional design. Further studies are needed to confirm that.

KEYWORDS: Post and core, Retrievability, Fracture resistance, and Microleakage.

CLINICAL IMPLICATION The experimental design may offer clinicians the possibility of safely removing post/crown and successfully reposition them without need of constructing new crown.

1. INTRODUCTION

Longevity of full coverage crowns is ruled by different factors including preparation design, cementation protocol and fabrication material (Addy and Hayes, 2007; Chandra., 2009). Despite the marked improvements in fabrication materials and technologies, complications such as veneer fracture, pain or need for endodontic retreatment might arise and necessitate crown removal (Goodacre et al., 2003; Rossetti et at., 2008). Moreover, trying to accomplish endodontic retreatment without removing the crown by cutting an access cavity in the occlusal surface may complicate endodontic retreatment and lead to failure (Kelly et al., 2014; Scotti et al., 2013). This may be because, the existing crown might hinder accurate radiographic or clinical examination preventing the total elimination of the causative pathological factors. Furthermore, in the case of veneer fracture, attempts for intraoral repair using composite are often difficult to perform and of with poor esthetic outcome (Gregory and Powers, 1988; Welsh and Schwab, 1977).

Many devices have been designed over the years for crown removal (Pruitt., 1994; Cranska., 2015). Often, the clinician is unable to identify the core materials and cements used, if it was previously completed by different clinician, making its removal quite a challenge. In addition to that, attempts to accomplish successful removal using conventional crown removers may be complicated by veneer fracture, crown fracture or even tooth fracture (Näpänkangas and Raustia, 2008).

The situation may be further complicated by the presence of a post that also needs to be removed before endodontic retreatment. Posts can be removed by a number of techniques (Stamos and Gutmann,1993; Masserann., 1966). Some may require removal of large amounts of sound tissue (Mitsui et al., 2004) and may result in root fracture or perforation rendering the tooth hopeless and doomed for extraction (Addy and Hayes, 2007).

Moving to implant-supported prosthesis, screw-retained prostheses (Prestipino et al., 2001; Schweitzer and Mancia, 2011) were preferred by many clinicians over cement-retained prostheses, due to their safe retrieval of the super-structures in case of fracture repairs, or abutment-screw tightening with simplicity and predictability. Unfortunately, this is not the case regarding conventional tooth-supported crowns (Ma and Fenton ,2015; Kosinski., 2015).

Questions worth asking: Can conventional tooth-supported crowns be retrieved safely with simplicity and predictability in cases of need and reinserted again? Can the same concept of screw-retained prostheses be applied to conventional tooth-supported crowns?

The aim of this study was to evaluate an experimental two-component retrievable crown design in which the crown could be retrieved intact without compromising both crown and tooth and possibility of repositioning it again. The proposed hypothesis was that the experimental design will have comparable fracture resistance, microleakage values, but superior retrievability compared to the conventional design.

2. MATERIALS AND METHODS

A total of 120 freshly extracted human maxillary second premolars were collected form orthodontic patients. Teeth were cleaned and sterilized in an autoclave at 121°C, 15 Psi for 30 min., and were stored in 0.9% sterile normal saline not more than 3 months before testing. Anatomical crowns were removed 2 mm coronal to cement-enamel-junction leaving approximately 16 mm of root length.

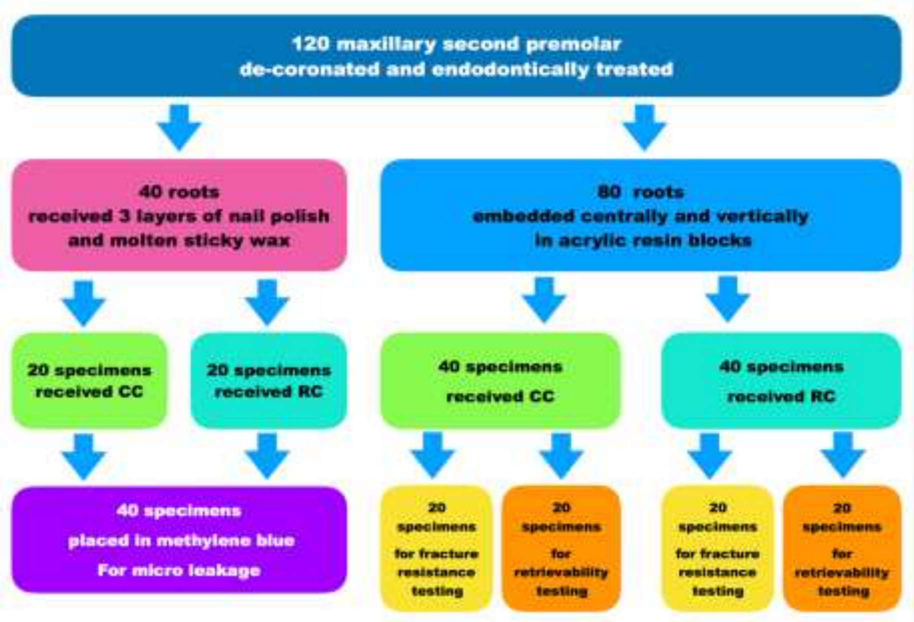

Fig.1: Procedural flow of specimen preparation

For microleakage testing, 40 roots were dried and received 3 layers of nail polish leaving the coronal root face, nail polish-free. Each root was dipped in container filled with molten sticky wax (Keystone Industries) to the level of apical one half of root and left to dry, shown in figure 1 above.

Remaining 80 roots were embedded centrally and vertically to a depth 2 mm below the cemento–enamel junction in 10×10×20 acrylic resin blocks (Vertex-Dental B.V.). Root canals were prepared corono-apically using rotary instrumentation (Miltex Inc.) and obturated with gutta-percha points using lateral condensation technique. Specimens were placed in distilled water at room temperature for 72 hours. Post channel preparations was initiated by the removal of 10 mm of gutta-percha with Gates Glidden #1 drills (Dentsply Maillefer) then using Peeso reamers #1 to #3 (Largo; Dentsply Maillefer).

Manufacturer supplied post drills were then used to finally prepare the post channel. Apical plug of 6 mm was left intact as recommended to resist apical microleakage. All post channels were thoroughly flushed using NaOCl then distilled water and later dried using paper-points. A 1.5 mm ferrule with 1 mm thickness heavy chamfer finish line was prepared on all roots using round-end taper diamond bur with guiding pin (Komet, Brassseler) in a parallelometer (ap100; AMANN GIRRBACH).

Specimens were randomly assigned to 2 equal groups according to crown design as follows; half of the prepared specimens (n=60) received modified threaded titanium post (Rotex; CENDRESR& ME TAUX SA), composite core and metal coping (CC) while the other half received two-component retrievable crown design (RC).

2.1 Specimens' preparation for CC group:

Post-holes were injected with glass ionomer cement (GIC) (Ketac Cem aplicap; 3M ESPE) following manufacturer's directions. Posts were screwed into post-holes until seated. After removal of excess cement, root face was etched for 15 sec using 32% phosphoric gel (Scotchbond Universal Etchant; 3M ESPE).

Bond (Adper Single Bond 2; 3M ESPE) was applied for 15 sec and thinned out. Coronal cores were constructed using light polymerizing composite resin material (Z 350; 3M ESPE) in preformed transparent shells (ParaForm Coreformer; Coltène Whaledent), shown in figure 2 IB. Specimens were digitally scanned using (S 50 Zenotec CAD, Wieland Dental) and anatomical Chrome Cobalt (Cr-Co) copings representing maxillary second premolar were fabricated using Selective Laser Sintering technology (SLS). (Figure 2 IA) Copings were cemented using GIC following manufacturer's directions under 5 kg. Static for 10 min. Excess cement was removed using scaler in an occluso-cervical direction.

2.2 Specimen preparation for RC group:

Experimental design is composed of 2 parts; a) coping with post access-channel having 0.5 mm wall thickness and 2 mm central hole to accommodate for the post entrance . (Figure 2 IIC) b) custom modified parallel-sided active titanium post. It was modified through removing lower 1 coronal flange rendering radicular part taller. (Figure 2 IID) (Figure 3B) Specimens were digitally scanned and Cr-Co copings having post access-channel were SLS exactly as in group CC.

GIC was injected into the post-hole and applied on the root-face surface of all coping which was then placed on the root face. Posts were inserted through access-channels into the roots. Excess cement was removed from around the coping and around post-head. After cement setting, gutta percha plug was placed on post head, as shown in figure 2 IIB, and on top of it composite plug was applied to close the access-channel, as shown in figure 2 IIA.

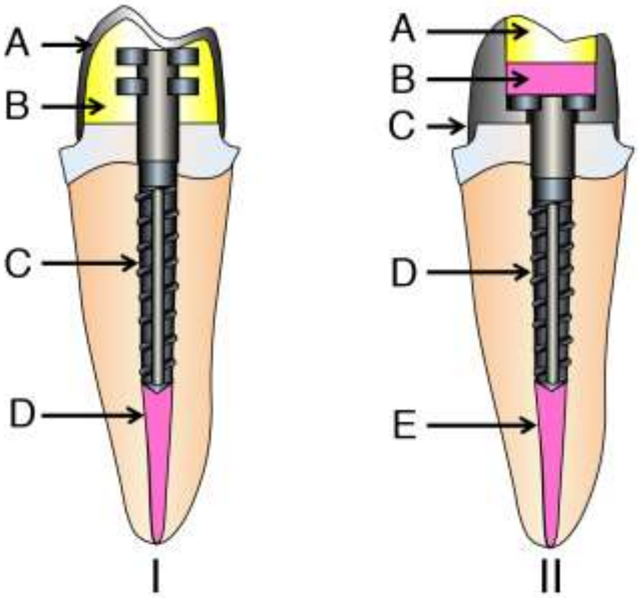

Fig.2: Schematic drawing I: CC component; A: Cr Co coping B: Composite resin core C: Threaded post D: Apical Gutta Percha plug. II: RC Component; A: Composite plug B: Gutta Percha plug C: Coping with post access-channel D: Custom modified parallel-sided active titanium post E: Apical Gutta Percha plug.

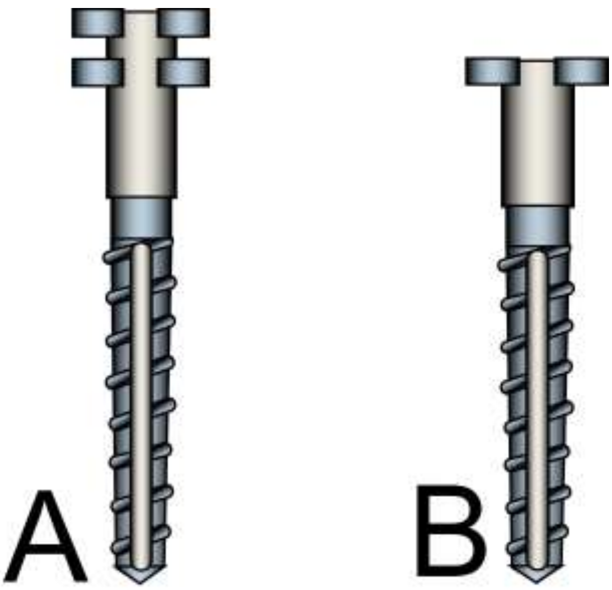

Fig.3: A: parallel-sided active titanium post B: Post after removing lower 3 coronal flanges rendering
Reference: The authors - April 2019

Specimens in both groups underwent thermal cycling in water bath between 5°C and 55°C for 15,000 cycles at 30 sec for each cycle and 15 sec of dwell time.

2.3 Microleakage testing.

Forty specimens (n=20 in each group) were submerged in 2% methylene blue solution (Natufarma Pharmacy) at 37º C for 12 hours. All specimens were washed under running tap water to remove excess colorant for 10 min and dried. Sticky wax and nail polish were scraped off with a scalpel and specimens were left to dry for 2 days. All specimens were sectioned longitudinally in a bucco-lingual direction through root center till the apex, using low-speed diamond saw under constant water-cooling. Sectioned roots were examined under a stereomicroscope (SZX7; Olympus). A 0 to 4 nonparametric scale was used to score dye penetration in the dentine cement interface; 0 = no leakages, 1 = leakage reached within or exactly at end of coronal third of root, 2 = leakage reached within or exactly at the end of middle third of root, 3 = leakage reached full length of axial wall, and 4 = Leakage over apical foramen (Baldissara et al., 1998).

2.4 Fracture resistance testing.

One mm thick tin foil sheet (Keystone Industries) was placed between loading tip and occlusal surface of coping to avoid local stress concentration. Specimens were individually mounted onto lower fixed head of computer-controlled materials testing machine (Model 3345; Instron Instruments Ltd) with a load cell of 5 kN. Ninety degrees vertical load was applied to the center of occlusal surface with crosshead speed of 0.5 mm/min until fracture.

2.5 Retrievability test:

Twenty specimens of each group were randomly distributed equally between 5 prosthodontists who were instructed to try to remove both crown and post following the following steps:

For CC group: each prosthodontist was handed sliding-weight crown remover, crown cutter bur, diamond bur, crown splitter and post screw driver. Prosthodontists were instructed to attempt to remove copings using crown remover first then use the crown cutter and crown splitting tool. Using diamond bur composite core was removed from coronal portion of post and attempts to unscrew post were made.

For RC group: each prosthodontist was handed diamond bur , probe and post screw driver. Prosthodontists were instructed to remove composite plug covering the screw head using diamond bur and gutta percha plug using probe. Then attempts to unscrew post were made. Retrievability of posts were graded according to a 0 to 2 scale; 0 = Coping Retrieved and re-placed with the same post, 1= Coping Retrieved and replaced with another post and 2= Coping Failed to be retrieved intact (fracture of root , post or damage to post head).

To consider specimen retrievable, coping and post should be removed completely of root. Coping and root should be intact. Specimens were inspected for damage after retrieval according to 0 to 3 nonparametric scale; 0=No damage to coping or root , 1= damage to coping not root, 2= no damage to coping with damage to root, 3=damage to both coping and root.

Carefully remove the post and access the post channel. Roots were examined under stereomicroscope in order to assess any structural damage.

2.6 Statistical analysis:

Data were summarized using mean and standard deviation for quantitative variables and percent for qualitative variables (SPSS version 17; SPSS Inc.). Shapiro-Wilk test were used to detect presence of normal distribution in the data and non-parametric Mann-Whitney test for abnormally distributed quantitative variables while T test for normally distributed data. An alpha level of.05 was used as a decision point for statistical significance.

3. RESULTS

3.1 Fracture resistance (FR) test:

Shapiro-Wilk test detected normal distribution of data in all the studied groups, as a result, parametric statistical test was used. Mean, Standard Deviation, Minimum and Maximum of Fracture Resistance and tensile strength values are displayed in table 1 below.

T-Test at 95% of confidence level, determined high level of significance among the tested groups for FR test (P-Value=.000). RC group had significantly higher resistant to facture loads. (P<.5) RC group showed higher mean fracture resistance than CC group.

Observing failure modes in all groups, CC groups showed more core and root fractures, while RC group showed more post fractures with less root fractures.

Table 1: Mean, Standard Deviation, Minimum and Maximum of Fracture Resistance and tensile strength values (in newton)
Reference: The authors - April 2019

Studied Variable	Studied Group	N	Mean	Std. Deviation	Std. Error	Min	Max
Fracture Resistance	RC	20	322.50	31.76	7.10	282	395
	CC	20	216.20	42.80	9.57	136	281

3.2 Microleakage test:

Dye staining was evident to some degree in most of the specimens. Mann-Whitney U Test revealed at the confidence level of 95% a non-significant difference in dye-penetration depths between the two tested groups with P-Value = .342. Microleakage percentages are shown in figure 4.

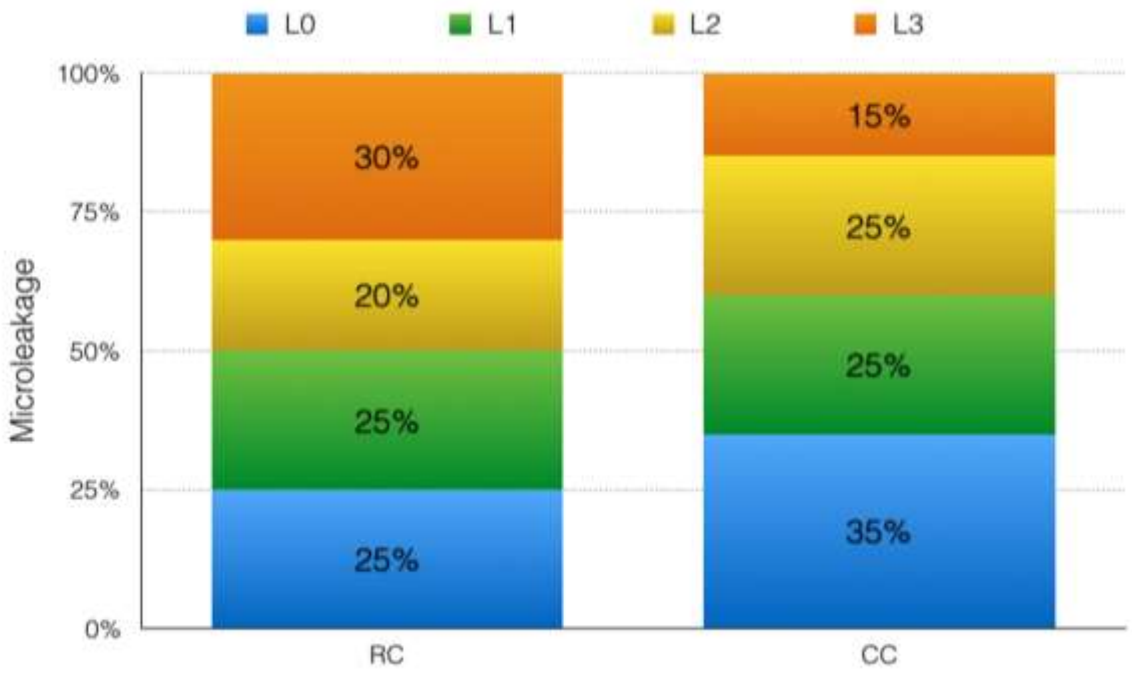

Fig.4: Microleakage Percentage among studied groups. L0: no leakages, L1: leakage reached within or exactly at end of coronal third of root, L2 : leakage reached within or exactly at end of middle third of root, L3: leakage reached full length of axial wall, and L4: Leakage over apical foramen.
Reference: The authors - April 2019

3.3 Retrievability test:

Eighteen specimens in RC group and no specimens in CC group were retrievable. Ninety Percent of RC group where irretrievable while 100% of CC group were irretrievable. Chi Square test results revealed significant difference between the tested groups; P-Value 0.003. Retrievability analysis was listed in table 2 below.

Table 2: Retrievability analysis of tested groups
Reference: The authors - April 2019

Groups	Coping Retrieved intact and re-placed with the same post	Coping Retrieved intact and re-placed with another post		Coping Failed to be retrieved intact
		Damage in post head	Post not retentive in canal	
RC	11	3	4	2
CC	0	0	0	20

4. DISCUSSION:

The aim of the current study was to introduce an experimental post-crown design that would facilitate a safe removal of the crown and post with a minimal risk of root fracture during the process. The design was inspired from screw-retained implant supported restoration. In attempt to mimic the mechanism by which a crown is screw retained to abutment in implant supported restorations. The prepared root would serve as the fixture that would receive the post and crown, retained by post screws simulating implant and screw-retained crown, as shown in figures 5-8.

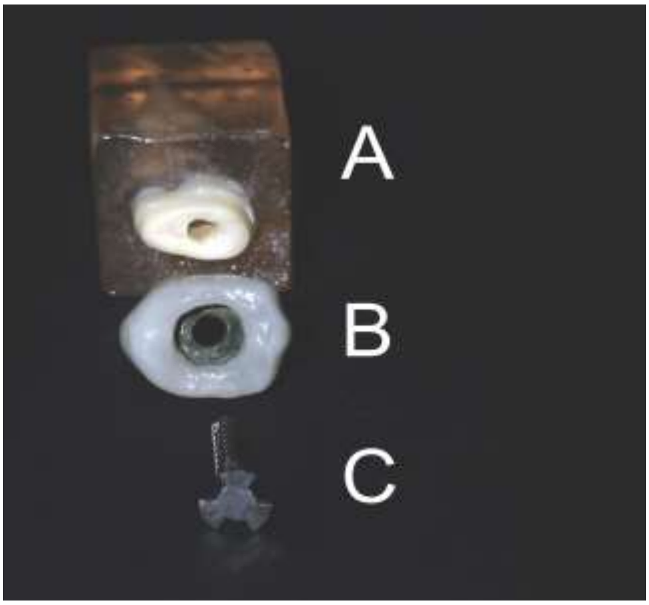

Fig. 5; RC Design, A: Roots in acrylic resin blocks. B: Retrievable PFM crown C: Custom altered parallel-sided active titanium post.
Reference: The authors - April 2019

Fig.6: RC Design, Retrievable PFM crown secured to root.
Reference: The authors - April 2019

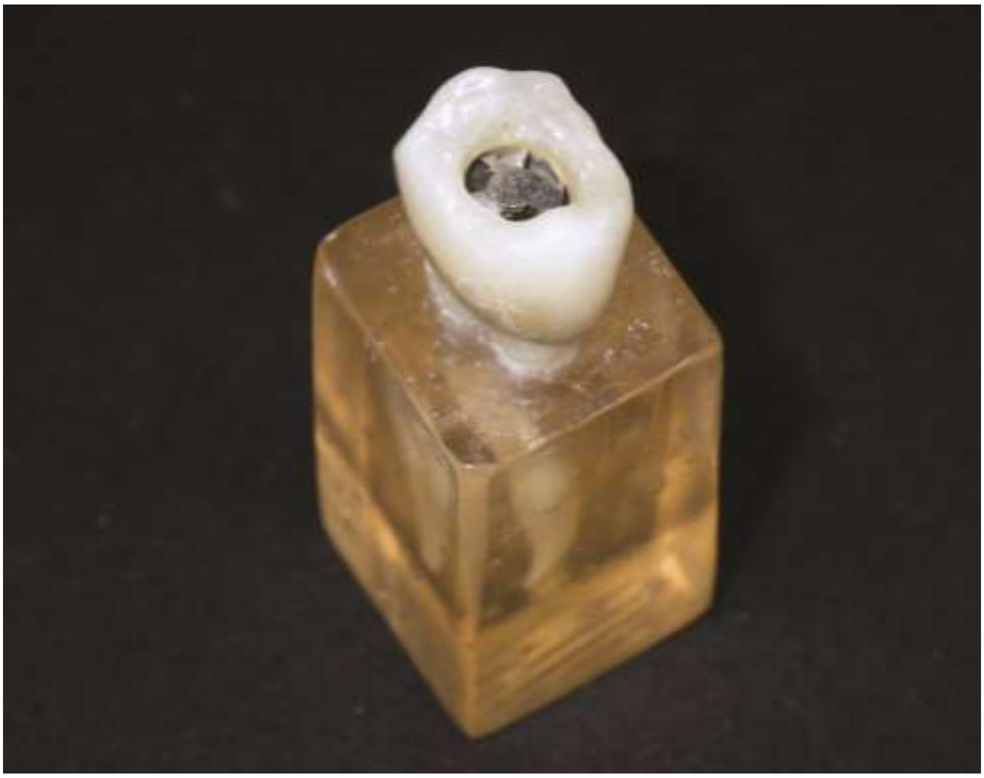

Fig.7: RC Design, Posts inserted through access-channels into root and cemented.
Reference: The authors - April 2019

Fig.8: RC Design, Composite plug applied to close access-channel.
Reference: The authors - April 2019

This concept if applied to tooth will have benefits of ability to remove the restoration and the post and to apply any procedures within the root confines like endodontic retreatment, and reapplying the same restoration again without the need for new restoration because the finish line was not modified.

This is unlike the conventional post-crown prostheses that lack this advantage, as they can only be removed by splitting or by crown remover instruments that occasionally render the crown destroyed and unusable. Even if the crown was removed without splitting, construction of a new one is a must.

The difference between experimental design and implant supported design is that: the restoration screw is tightened to the metal inside implant. While restoration screw in RC is a post and screwed to root canal. Repeated unscrewing could decrease the retention between the post and canal wall and necessitates use of wider post.

In addition , opposite to implants prostheses, any gap between the restoration base and the root face may cause caries and bad odor. Consequently, that gap should be filled. Glass ionomer cement doesn’t function as cement because the restoration is already screwed to the root, but as a gap filler preventing any complication that may arises of coronal microleakage.

Among drawbacks of RC design that it needs sophisticated work at the laboratory. That could be justified in order to gain more benefits of definitive restoration. Another drawback is the cement applied around the post and under restoration which act as a space filler. This cement makes it more difficult during attempts to retrieve experimental crowns . Nevertheless, the design showed promising breakthroughs; they are nearly equal to the conventional design in coronal microleakage. But surpass the design in fracture resistance and their ability to be retrieved and reinserted again 90% of specimens were successfully retrieved. A space filler having ability to close the space with low mechanical properties to be easier to be retrieved could be justified.

Limited microleakage patterns were revealed in few specimens around posts in both groups. Root canal preparation technique used in current study paid attention to conditioning the dentinal surface of the root, using glass ionomer cement, selection of post size and diameter that matches closely to the selected drill, and proper obturation technique all together which reduced microleakage in the tested specimens.

Regarding fracture resistance, RC group demonstrated higher mean fracture resistance than CC group, which may be explained by the absence of composite core in RC group, which may be the cause of early failure records. It is worth mentioning that 40% of the samples underwent root fracture in CC group and no root fractures in RC group.

Although there is no standardized "retrievability test" in literature, it was very important to suggest such a test to compare the between both designs in that area. Regarding retrievability; CC group, most of attempts ended up with damaged post head, fractured post or root, rendering the tooth hopeless and indicated for extraction. This may be attributed to the clogged post-head with core material that hindered any attempts of unscrewing of posts. On the other hand, most of posts in RC group were retrieved, with no root fractures. The specimens that failed to be retrieved were due to damage of post head from manipulation. Post head design modification may be beneficial for better performance.

One could argue that caries could attack the fitting surface of the experimental design. But according to microleakage results there was no significant difference between both designs in dye penetration.

A drawback in the study is the use of natural teeth that are very diverse. It was necessary, however because in studies around posts it is a must that they engage radicular dentine, for more accurate results. This is difficult to replicate in epoxy dies.

Based on the previous data, RC design showed promising results; they were nearly equal to the conventional design in coronal microleakage. But surpass the design in fracture resistance and their ability to be retrieved and reinserted again. Regarding hypothesis, the part regarding fracture resistance was rejected. While the part regarding microleakage and retrievability was accepted.

5. CONCLUSION

Within limitations of current study, the proposed retrievable crown design showed promising results and maybe considered a restorative option in endodontically treated teeth. Further studies are needed to confirm that.

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