ASDJ
AINSHAMS DENTAL JOURNAL

Print ISSN 1110-7642
Online ISSN 2735-5039

AIN SHAMS DENTAL JOURNAL
Official Publication of Ain Shams Dental School
March 2025 • Vol. 37

In Vitro Study Comparing Fracture Resistance of Two Hybrid Ceramic Endocrown Materials with or without Short Fiber Reinforced Composite Base

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Aim: The study purpose was to compare the fracture resistance of different hybrid ceramic endocrown materials either with fiber reinforced composite resin base or without it.
Materials and methods: Forty extracted sound mandibular molars were selected for endodontic treatment and then cut 2mm above the cementoenamel junction, Samples randomly classified into two main groups (n=20 each) according to the material of endocrown fabrication (Vita Enamic, Brilliant Crios), then subdivided into two subgroups (n=10) according to the reinforcement with composite resin base or not inside the pulp champers. CAD\CAM milling of endocrowns and cementation were performed according to manufacturer instructions. A chewing simulator was used for all samples (1,200,000 chewing cycles) in conjunction with thermocycling, then were subjected to compressive load until fracture using universal testing machine. Quantitative data was collected, tabulated and statistically analyzed using one way analysis of variance and Tukey's post hoc test.
Results: There was a highly significant difference between the studied groups with the highest value of fracture strength recorded in Brilliant Crios endocrowns with FRC base while the lowest value was in Vita Enamic endocrowns without FRC base.
Conclusion: Hybrid ceramic endocrowns showed an accepted fracture strength to resist the masticatory forces, while using short fiber reinforced composite base enhanced the fracture strength but without a significant value.

Keywords: Endocrown, Hybrid Ceramics, Fiber reinforced composite, Fracture Resistance.

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Introduction

The dentin characteristics and function of teeth that had endodontic therapy can be affected by a variety of factors, including structural loss, loss of vitality, and the materials and techniques utilized during the treatment.[1]

Usually, endodontically treated teeth subjected to failure of tooth\coronal restoration complex followed by cusp fracture. The endodontic treatment itself decrease the tooth stiffness by 5%, while MOD cavities decrease its stiffness more than 60% so its restoration is a challenging procedure.[2,3]

Post and core with full coverage restoration was used as a first option of treatment plain to restore endodontically treated teeth with sever loss of its coronal structure, but the remaining radicular dentin after preparing the post space channel was weakened and may cause fractures under occlusal forces in posterior teeth.[4,5]

Endocrowns, a substitute for post and core, emerged as a therapeutic alternative option for teeth that had undergone endodontic therapy as adhesive technologies became advanced. A micromechanical adhesive system and a macro-mechanical extension into the pulp chamber and the cavity edges provide two methods of retention for an endocrown, an indirect adhesive restoration with an intraarticular part that acts as an overlay or cusp covering.[6] Restoring endodontically treated teeth with endocrown showed higher fracture resistance than those restored with post and core with full coverage crown as it preserves the peripheral enamel, which improve the adhesion process with a positive effect on stress distribution and fracture resistance.7 Although endodontic crowns improved the mode of failure for treated teeth, some teeth still fail irreparably, especially when subjected to lateral stresses.[7]

Preparation design, restorative material selection, and stress reduction base application are three ways to lessen the endocrown failure mode. (bases that absorb shock). Fiber reinforced composite materials help in decreasing the likelihood of root canal treated teeth cracking.[8]

Because of its excellent adhesion to the cavity walls, fiber-reinforced composite material distributes occlusal loads uniformly throughout the tooth. As the degree of polymerization increases, the amount of light that can pass through the fibers grows. Because the polymerization contraction of SFRC is less along the fiber's long axis, the material has far less volumetric shrinkage when compared to other composites.[9,10,11]

Ceramic materials with varying physical and chemical characteristics have proliferated alongside CAD/CAM technologies. The main target of the dentist is to decrease the risk of failure or fracture while maximizing the desired aesthetic and functional outcomes when choosing a material.[4]

The advantages of ceramics (such as their longevity, biocompatibility, and aesthetics) and nanopolymers (such as their stress distribution and flexure strength) have been combined in new hybrid ceramics. Because of their modulus of elasticity, which is comparable to that of dentin, hybrid nanoceramics distribute stress and alleviate pressure on the dentin walls.[12]

To make Vita Enamic, a hybrid ceramic material with high flexural strength values and elasticity, a monomer combination is first infiltrated into a porous ceramic foundation structure. This gives the material the best properties of both ceramics and composites.[13]

One type of nanohybrid composite, called Brilliant Crios, is composed of 71% An inorganic filler composed of 20 mm silica and 1 mm barium glass embedded in a strongly cross-linked methacrylate matrix creates a monoblock that mimics dentin in terms of modulus of elasticity. This allows the tooth and restoration to function as one cohesive unit, distributing stresses more evenly than glass ceramics.[14]

So, it was intriguing to see how two hybrid ceramic endocrown materials, one with and one without a fiber reinforced composite foundation, compared in terms of fracture resistance for teeth that had undergone endodontic treatment.

Material and methods

The study design

The research used a controlled in-vitro experimental design.

Ethical Considerations

The purpose of the present study was explained to the patients and informed consents were obtained to use their extracted teeth in the research according to the guidelines on the human research adopted by the Research Ethics Committee, Faculty of Dentistry, Tanta University with number (#R - RD- 11 – 23 – 3082).

The study setting

This in-vitro study was conducted in Fixed Prosthodontics Department. While the laboratory test was carried out at Dental Biomaterial Department. Both was conducted in Faculty of Dentistry, Tanta University

Sample size

The total number of sample sizes for this study is 36 samples. The samples were collected based on a pilot study. The significance level was 0.05 and the power sample size was more than 80% for this study and the confidence interval 95% and the actual power is 97.16%The sample size calculated using a computer program G power version 3.1.9.

The formula of sample size

$$sample\ size = \frac{Z^2\hat{P}(1-\hat{P})}{C^2}$$

Where:

Z = Z value (1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal

c = confidence interval, expressed as decimal.

The sample size was 40, which was intentionally inflated to account for the possibility of failure and enhance the reliability of the data.

Statistical analyses were conducted using SPSS version 26, which is a statistical package for the social sciences. Descriptive statistics were used to convey numerical variables like range, standard deviation, and mean, while percent, median, and frequency were used to depict nominal data. If P value is less than 0.05 (*) it refers to significant difference, while being less than 0.001 (**) a highly significant difference was detected.

Specimen collection and preparation

Recently extracted forty human sound mandibular molars (for orthodontic or periodontal reasons) were collected from the Oral and Maxillofacial Surgical Department of Faculty of Dentistry, Tanta University. An approval from the Research Ethics Committee of Tanta University was received. The teeth were intact, free from caries or any fillings, without cracks, fractures or wear. To ensure consistency, a digital caliber was used to measure The selected molars buccolingually and mesiodistally at the CEJ to ensure having similar dimensions as much as possible, and also the dimensions of the selected teeth from the level of the proximal cemento-enamel junction were measured.[15]

The teeth were cleaned, scaled, and polished with rotary brush and pumice, then using saline solution for storage the teeth in room temperature throughout all testing durations to keep them hydrated. Specimens were embedded in acrylic resin blocks vertically using dental surveyor.

The roots were immersed in molten wax (Cavex, Holland B.V.) to create a uniform layer around the root. After the acrylic resin had fully set, the wax spacer was removed and polyvinyl siloxane material was injected to mimic the periodontal ligament, which is approximated to be about 0.3mm around the root.[15]

Endodontic treatment was performed on all teeth using rotary files (Dentsply Maillefer, Switzerland) following the manufacturer's specifications. Gutta percha was then used to seal the openings.

Standardized Tooth Preparation for endocrowns

A computerized numerical control (CNC) milling machine (C.N.C Premium 4820, imesicore, Eiterfeld, Germany) was utilized in selected preparation design (Butt joint) to ensure that all teeth had a uniform preparation dimension as it holds a high-speed handpiece with flat end tapered diamond stone (10◦) of taper to allow a standardized coronal degree of convergence. Starting with occlusal reduction depth orientation grooves was created 2mm above cemento-enamel junction that measured from proximal surface, followed by using coarse diamond wheel that held parallel to the occlusal plane to create a smooth flat horizontal margin.

The internal cavity began with removing any undercuts rounding internal angles and eliminating recesses in the pulp chamber with maintenance of its morphology then achieving divergence internal walls with (8-10◦ taper) using tapered diamond bur perpendicular on the pulpal floor with 5mm internal cavity depth that measured using graduated periodontal probe. Preparing and adjusting the cavity margins with a uniform thickness of approximately (3 ±0.5mm) using digital caliper for measuring a standard dimension.

For scanning the preparation an intraoral scanner (Cerec Omnicam, Sirona Dental Systems, Germany) was used, followed by merging and saving the information as STL file.[16,17]

Randomization: All samples were numbered from 1 to 40 then by using the web site (www.Random.org) classified into 4 equal groups.[18]

Samples grouping

Samples were classified into two main groups (n=20 each) according to the material of endocrown fabrication, then each group was divided into two subgroups (n=10) according to the reinforcement with composite resin base or not inside the pulp champers as follow:

G1: Vita Enamic endocrown (hybrid ceramic) with 1mm fiber reinforced composite resin base (EverX posterior)

G2: Vita Enamic endocrown (hybrid ceramic) without 1mm fiber reinforced composite resin base (EverX postrior)

G3: Brilliant endocrown (hybrid nanoceramic) with 1mm fiber reinforced composite resin base (EverX posterior)

G4: Brilliant endocrown (hybrid nanoceramic) without 1mm fiber reinforced composite resin base (EverX posterior)

Designing the restoration

After selecting the desired design and matching tooth number by using software program (exocad, exocad GmbH), the restorations were custom-made for each tooth using standardized measurements. This system was used to obtain a three-dimensional image of the prepared tooth as the tooth was sprayed with using Teles can light reflection powder (Vita Zahnfabrik, Germany) to create an optical impression of the samples. Scanning with identical blue with automatic marginal finder to determine the preparation margins. Thus, the STL file was created for the purpose of milling with a CAD/CAM machine (Figure 1) that showed the finally milled Brilliant Crios endocrowns.[19]

Figure 1: the milled CAD\CAM Briliant Crios endocrown

Restoration of the prepared cavities

Groups 1 and 3: 2mm of FRC base (EverX posterior fibers) were built-up in layering manner, and the cavity depth was measured from the level of cervical margin 3mm.

In **Groups 2 and 4:** the prepared cavity without application of any base, the cavity depth was measured 5mm from the cervical margin level.

Cementation of endocrown restorations

Surface treatment of the prepared tooth surface: it was etched with 37% phosphoric acid etching gel for 15 seconds and rinsed for 20 seconds using a water syringe. After that, dried for 5 seconds.

Treating the intaglio surfaces of each restoration: it was sandblasted with 50Mm aluminum oxide particles for 10 seconds with 2.5 bar pressure from 10mm distance then decontaminated in ultrasonic cleaners, rinsed and dried. After sandblasting the inner surface was etched with 9.5% hydrofluoric acid for 20 sec, rinsed for 20 sec and dried.

A single-bond adhesive layer (3M ESPE Neuss, Germany) was introduced to the inner surface of endocrowns for 20 seconds then air-thinned.

The adhesive system {single-bond universal (3M ESPE Neuss, Germany) was applied in the form of two separate coats to the preparation using micro brush for 15 sec per coat excess solvent was evaporated by air for 5 seconds and polymerized using a LED light in accordance with the manufacturer's procedure. Then allowed to dry completely for 5 seconds.[20]

All endocrowns were cemented with Self-adhesive dual-cure resin cement (SoloCem, Coltène/Whaledent AG, Switzerland) following the manufacturer guidelines. It was introduced to the fitting surface of the restorations with gentle seating pressure on the tooth till complete seating was achieved, cementing device with 3-kilogram load was applied on the specimens after cement application for five minutes only to standardize a homogenous equally distributed thickness of cement layer under equivalent pressure, then any excess cement removed with brush.

To achieve proper setting process a layer of glycerin gel was applied to the restoration margins to protect it from oxygen inhibition during polymerization stage. Final curing for 20seconds\surface, using a blue phase light curing device (Ivoclar Vivadent AG, Schaan, Liechtenstein) [21]

As shown in (Figure 2) finally cemented Brilliant Crios endocrowns.

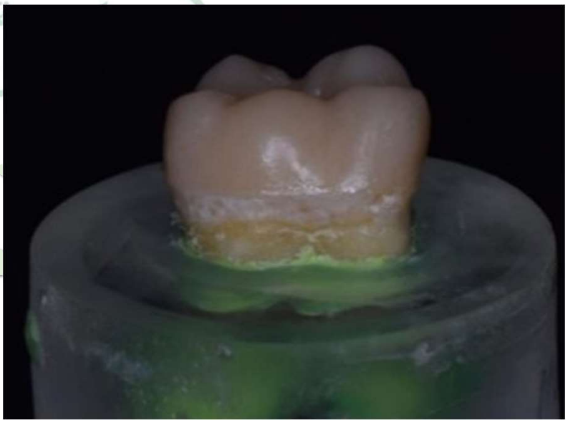

Figure2: finally cemented endocrown

Thermocycling and Chewing simulation

To simulate the intraoral conditions all specimens were subjected to chewing simulator with thermal cycles CSTC device (CS-4, SD Mechatronik, Germany) that consists of four testing chambers within the main thermocycling chamber. All specimens were subjected to 1,200,000 cycles using a 50N compressive load with a frequency of 1.6Hz at temperature ranging from (10 to 60°C).

It has two moving parts, vertical and horizontal axis. The samples mounted on a movable table that oscillates back and forth while a customized antagonist (4mm) in diameter connected to the vertical bar that moves up and down with a (5 Kg) load to simulate the intraoral masticatory forces. [22,23]

Fracture resistance test

Within the lower compartment of the universal testing machine (Model 3345; Instron Industrial Products, Norwood, MA, USA) each sample was mounted and subjected to a static increasing compressive load till failure. Using (5Kn load cell and 6mm diameter) stainless steel ball loading piston were used to apply the force vertically to the occlusal surface till fracture occurred, then recording the fracture load readings in Newton using computer software (Instron BluehillLite Software).

Statistical analysis

Statistical analyses were performed using Statistical Package for Social Sciences (IBM SPSS Statistics version 26). Numerical variables express by mean, standard deviation and range in descriptive statistics. P value <0.05(*) was considered significant difference & P-value <0.001(**) was considered highly significant difference. The tests used in this analysis:

- The one-way ANOVA was used to compare the results of fracture strength test at the studied group.
- The multiple comparison Tuckey test was used to compare between each two groups.

Results

Table (1), Figure (3): shows the results of Fracture strength test for the studied groups. Which is expressed by means, standard deviation and range, also shows the comparison between the studied groups using one way ANOVA test, which showed there was a highly significant difference between them with p-value 0.000**. The highest value of fracture strength showed in G4 (Brilliant Crios endocrown with FRC base (2032.08±74.35), while the lowest value showed in G1 (Vita Enamic endocrown without FRC base (1142.70±161.62).

Table1: Comparing the results of fracture strength of the tested groups using One-way ANOVA.

Groups	Fracture strength			
	$\bar{X}$±S.D	Range	One way ANOVA test	
			F	p-value
G1:vita Enamic endocrown without FRCbase	1142.70±161.62	934.90—1369.50	53.512	0.000**
G2: Vita Enamic endocrown with FRC base	1222.46±241.69	980.55—1679.88		
G3: Brilliant endocrown without FRC base	1840.55±238.44	1499.35—2027.87		
G4: Brilliant endocrown with FRCbase	2032.08±74.35	1893.77—2091.36		

The significant value as (P-value< 0.05 (*), and highly significant as (P-value< 0.001 (**).

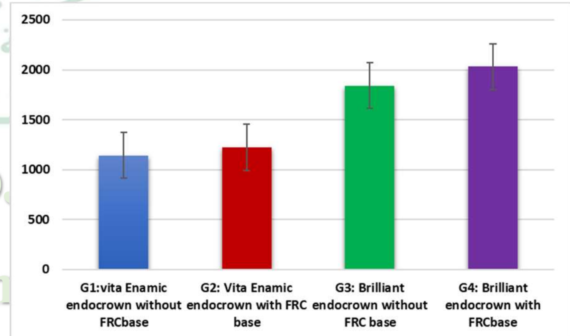

Figure 3: Shows the results of Fracture strength test for the tested groups

Table 2: Shows the multiple comparison Tuckey test, which was used to compare each two tested groups.

Groups	Multiple comparison (Tuckey test)		
	G1:vita Enamic endocrown without FRCbase	G2: Vita Enamic endocrown with FRC base	G3: Brilliant endocrown without FRC base
G1:vita Enamic endocrown without FRCbase	-------	-------	-------
G2: Vita Enamic endocrown with FRC base	0.789	-------	-------
G3: Brilliant endocrown without FRC base	0.000**	0.000**	-------
G4: Brilliant endocrown with FRCbase	0.000**	0.000**	0.133

The multiple comparison Tuckey test, which was used to compare each two groups, since there was a highly significant difference between group1 and group3 also group1 and group4 (0.000**), also there was a highly significant difference between group2 and group3 also group2 and group4, where there was no significant difference between group1 and group 2, also there was no significant difference between group3 & group 4 (0.133).

Discussion

Currently, we used Endo crown restorations which was created as other choice to post and core systems for reestablishing endodontically treated teeth with sever coronal damage as it enhances its fracture resistance and can be considered more conservative preparation (minimal invasive, preserve the peripheral enamel which promotes better adhesion and proper stress distribution of occlusal forces.[24]

Previous studies showed that endo crowns have been used in rehabilitation of endodontically treated incisors, premolars, and molars but it shows better performance in molars than premolars as smaller dimensions of premolar pulp chamber resulting in reduced bonding surface area and higher failure rate [25,26]

Govare and Contrepois suggested that endo crowns can be used as a better alternative to post retained restorations in molars as large surface area for adhesion. Therefore, the current study was conducted on molars.[27]

The strategy of fracture strength test in this study indicating that the forces used in vitro manage to simulate the stress situation causing fractures in vivo and utilized to predict the hybrid ceramic materials behavior and survivability under occlusal forces.[24]
Resin infiltrated ceramics are ceramics combined with resin matrix that were introduced to compensate the resilience found in dentin as they have a comparable modulus of elasticity to it. This allows better stress distribution, improves the fracture resistance, and decrease the catastrophic failure rates, so within the current study two sorts of resin infiltrated materials (Vita Enamic & Brilliant Crios) were chosen to evaluate its impact on stress distribution of endocrown restorations. Vita Enamic is a polymer infiltrated hybrid ceramic material and Brilliant Crios which is a new developed resin infiltrated material containing high percentage of resin loading.[4]

Fiber reinforced composite base used currently as it consists of short E glass fibers strands randomly distributed, these fibers responsible for diminishing polymeric shrinkage and achieving better and uniform stress distribution. A modern type of short fiber reinforced composite (ever x. posterior) was propelled recently, its properties like dentine supplanting materials because it contains short filamentous fibers and inorganic fillers embedded in a resin matrix.[28]

Periodontal ligament simulation was performed to imitate the real tooth behavior under masticatory forces, it acts as stress absorbing action. Also, all samples were exposed to thermocycling to resemble the clinical oral conditions in which the restoration subjected to a continuous thermal change in the oral cavity.[29]

Currently, thermocycling process in conjunction with chewing simulation was connected within the think about this in vitro study to subject the restoration tooth complex to different temperature extremes. This reenacts the fleeting presentation of the environment within the oral cavity and adjust the difference in thermal expansion between the tooth / restoration interface which may have deleterious effect on the restoration strength.[30]

Whereas chewing simulation considered the foremost widely used fatigue appliance because it mirrors the masticatory forces and the natural environmental situations that dental restorations subjected to it within the oral cavity so, it considered a great device to anticipate the clinical validity of distinctive dental restoration materials.[23] The null hypothesis of this study was somewhat rejected as the results cleared that there was a significant difference in the fracture strength values between the Brilliant crios and Vita Enamic endocrown materials, while using FRC base increased the fracture strength of both tested endocrown materials but without statistically significant difference.

Currently, Brilliant Crios endocrowns with or without FRC base showed the highest fracture strength values, these findings in accordance with Acar and Kalyoncuoglu studied the effect of using different types of hybrid ceramic materials on the fracture strength of endocrowns under different load directions, they concluded that Brlliant Crios showed the most appropriate fracture resistance than other hybrid ceramic materials used in the study.[24]

Also, the current results were in strong match with Eisa et al who assessed the fracture resistance of Vita suprinity, IPS e-max and Vita Enamic endocrowns and found that Vita Enamic had a comparable fracture load results to other materials, it was attributed to the close matching between the restoration materials and the natural teeth modulus of elasticity as well as the polymeric network within the ceramic matrix that leads to increasing its resistance to crack propagation.[20]

The current findings were supported by another previous study which concluded that Vita Enamic showed lower fracture strength in contrast with Brilliant Crios, which might be related to the difference in its structure and mechanical properties as it is attributed to ceramic loading occupying (86%) of its weight which affect positively on their hardness and brittleness.[31]

Brillian Crios moreover incudes a moderately low elastic modulus (10GPa) that is exceptionally near to dentin (11-19GPa) so both restorations and the underlying dentine experience a comparable degree of plastic deformation under exposing to masticatory forces. Another reality that is the likeness within the chemical composition between the Brilliant Crios blocks, the resin cement and the adhesive bonding agent which guarantees high bonding capacity as the bonding monomers enters the composite polymerized resin matrix to attain chemical and mechanical holding so that the prevalent fracture strength values of Brilliant Crios endocrowns credited to this high level of bonding.[24,32]

The current results disagreed with Ozocan et al who studied the internal fit and fracture resistance of resin ceramics compared to lithium disilicate, they concluded that lithium disilicate showed higher fracture resistance numerical data than resin infiltrated ceramics.[33]

The current study results showed that there was no statistically significant difference between G1, G2 (VitaEnamic endocrowns with FRC base and those without base), and between G3, G4 (Brilliant Crios with FRC base and those without base), that means using of FRC base didn't affect significantly on the fracture behavior of endodontically treated teeth restored with both hybrid ceramic endocrown restorations used currently.

These findings were in accordance with Rocca et al who reported that using FRC base under resin nanoceramic endocrown materials didn't enhance the fracture strength of endodontically treated molars.[34]

In contrast with Haridy and Mousallam who studied the effect of applying resin composite base materials on the fracture strength of endodontically treated premolars restored with Vita Enamic endocrown restorations, it was found that FRC base affects significantly on increasing the fracture strength.[15]

It also supported with another study by Otero et al who studied the influence of FRC base and bonded CAD\CAM resin composite endocrowns on the fatigue behavior of cracked endodontically treated molars and concluded that FRC base did not enhance the fatigue resistance, but it was better solution to manage crack propagation.[35]

This was attributed to three factors acting together: the sum of left unprepared tooth structure, with the amount of fortification (0.05mm vs 2mm) and the sort of fortification as the fiber reinforcement efficiency gets to be more noteworthy when the fibers introduced in a great amount, also long fibers accomplish way better reinforcement than brief short fibers may be due to the firmness of network.[36]

It was found that the restoration bulk thickness on the FRC base and the thickness of FRC base itself are important factors which affecting the fracture strength of endodontically treated molars with endocrowns as less restoration bulk between the fiber reinforced base and occlusal load bearing points become an appropriate tool for assessing the underlying variables (FRC type and thickness).[36]

The target of this study was to assess the durability of endocrown treated molars restored with differently selected hybrid ceramic materials with or without FRC base. The results of the current study showed that there were statistically significant differences of fracture resistance between the tested groups so, the null hypothesis was rejected.

Conclusion

within the limitation of this current study, it was concluded that

1. The tested hybrid ceramic materials were found to have an acceptable fracture strength to resist occlusal forces.
2. Higher fracture resistance values obtained with Brillant Crios in comparison to Vita Enamic material.
3. Fiber Reinforced Composite base increased the fracture strength of both tested endocrown materials but without statistically significant difference.

Recommendations for clinical practitioners

1. It is advisable to use hybrid ceramic materials in fabrication of endocrowns especially those containing high resin content as it has a promising better clinical biochemical behavior and better stress distribution of masticatory forces.
2. It is better to apply FRC base below the endocrowns to enhance its clinical longevity to withstand the occlusal forces without failure.

Funding: No funding was received for conducting this study.

Data availability: Data is available upon reasonable request from corresponding author.

Declaration: The authors declare no conflict of interest.

Ethics approval and consent to participate: The purpose of the present study was explained to the patients and informed consents were obtained to use their extracted teeth in the research according to the guidelines on the human research adopted by the Research Ethics Committee, Faculty of

Dentistry, Tanta University with number (#R - RD- 11 – 23 – 3082).

References

1. Tang W, Wu Y and Smales RJ. Identifying and reducing risks for potential fractures in endodontically treated teeth. J Endod. 2010;36: 609-17.
2. Vire DE. Failure of endodontically treated teeth: classification and evaluation. J Endod. 1991; 17:338-42.
3. Reeh ES, Messer HH and Douglas WH.Reduction in tooth stifness as a result of endodontic and restorative procedures. J Endod 1989; 15: 512-6.
4. Buyukbayram I K, Guven M E, Ayman D, Yamaner I D S and Cakan E F. Fracture resistance of resin endocrowns with and without fiber reinforced composite base material: A preliminary study. J.Appl.Biomater.Funct. Mater 2023; 00:1-10.
5. Krishan R, Paqué F, Ossareh A, Kishen A, Dao T and Friedman S. Impacts of conservative endodontic cavity on root canal instrumentation efficacy and resistance to fracture assessed in incisors, premolars, and molars. J Endod 2014; 40:1160–6.
6. Sedrez Porto J A, Rosa WL, Saliva A F, Munchow E A and Pereira C T. Endocrown restoraions: A systematic review and meta-analysis. J Dent 2016; 52:8-14.
7. El-Ghoul W, Ozcan M, Silwadi M and Salameh Z. Fracture resistance and failure modes of endocrowns manufactured with different CAD\CAM materials under axial and lateral loading. J Esthet Restor Dent.2019;31:378-87.
8. Eskitaşcıoğlu G, Belli S, Kalkan M. Evaluation of two post core systems using two different methods (fracture strength test and a finite elemental stress analysis). J Endod. 2002; 28:629 - 633.
9. Kaur B, Gupta S, Grover R, Sadana G, Gupta T, Mehra M. Comparative Evaluation of Fracture Resistance of Endodontically Treated Teeth Restored with Different Core Build-up Materials: An In Vitro Study. Int J Clin Pediatr Dent. 2021; 14:51-58.
10. Schwartz RS and Robbins JW. Post placement and restoration of endodontically-treated teeth: A literature review J Endod.2004;30:289-301.
11. Sorensen JA and Martinoff JT. Intracoronal reinforcement and coronal coverage: A study of endodontically-treated teeth. J. Prosthet. Dent. 1984; 51:780- 4.
12. Yamaguchi S, Kani R and Kawakami K. Fatigue behavior and crack initiation of CAD\CAM resin composite molar crowns. Dent Mater.2018;34;1578-84.
13. Dirxen C, Blunck U and Preissner S. Clinical performance of a new biomimetic double network material. Open Dent. J. 2013; 7:118-22.
14. Elsharkawy M A. Marginal adaptation and fracture resistance of endocrown restorations constructed from two CAD\CAM blocks. Egypt. Dent. J. 2021; 67:1-14.
15. Mosallam R and Haridy M. Fracture Strength of Endodontically Treated Teeth Restored with Endocrown restorations with /without Resin Composite Base Materials – An in vitro study. Egypt. Dent J. 2019;65:2837–48.
16. Deliperi S, Alleman D and Rudo D. Stress-reduced Direct Composites for the Restoration of Structurally Compromised Teeth: Fiber Design According to the "Wallpapering" Technique. Open Dent J. 2017;42:233-43.
17. Ille C, Moacă EA, Pop D, Goguță L, Opriș C, Pîrvulescu IL, Avram L, Faur A and Jivănescu A. Compressive strength evaluation of thin occlusal veneers from different CAD/CAM materials, before and after acidic saliva exposure.Odontology. 2023;111:360-74.
18. Riyad A, El-Guindy JF and Kheiralla LS. Tensile Bond Strength of (PEEK) vs Lithium Disilicate Endocrown. (An Invitro Study). ASDJ 2020; 19:1-8.
19. Shalaby M and Abo-Eittah M. Influence of the Preparation Design and Aging on the Vertical Marginal Gap of Occlusal Veneers Constructed of Different Ceramic Materials. Egypt Dent J. 2020;66:1261–74.
20. Eisa NS, Essam EA, Amin RA and Sharkawy ZR. Fracture Resistance and Retention of Three Different Endocrown Materials. ADJ-for Girls 2020; 7:190-8.
21. Elbasty, R., Eltannir, A., Shaker, A. Vertical marginal gap distance and retention of different CAD/CAM ceramic endocrown with two preparation designs. Egypt Dent J. 2017;63:755-67.
22. Saadeddin N, Al-Khalil MA and Al-Adel O. Effect of immediate dentin sealing on the fracture strength of lithium disilicate ceramic onlays. Swiss Dent J. 2022;132:482–9.
23. Smran A, Abdullah M, Ahmed NA, Al-Maflehi N and Samran A. Influence of Thermal and Mechanical Load Cycling on Fracture Resistance of Premolars Filled with Calcium Silicate Sealer. Appl.Sci.2023;13:4388-400.
24. Acar DH and Kalyoncuoglu E. The fracture strength of endocrowns manufactured from different hybrid blocks under axial and lateral forces. Clin Oral Invest 2021; 25:1889-97.
25. Dejak B and Mlotkowski A. Strength comparison of anterior teeth restored with ceramic endocrowns

vs custom made post and core. J. Prosthodont. Res. 2018; 62:171-6.
26. Guo J, Wang Z, Li X, Sun C, Gao E and Li H. A comparison of the fracture resistances of endodontically treated mandibular premolars restored with endocrowns and glass fiber post core retained conventional crowns. J. Adv. Prosthodont.2016; 8: 489-93.
27. Govare N and Contrepois M. Endo crowns: A systematic review. J Prosthetic Dent.2020; 123:411-8.
28. Mangoush E, Garoushi S, Lassila L, Vallittu PK and Sailynoja E. Effect of fiber reinforcement type on the performance of large posterior restorations: a review of in vitro studies. Polymers 2021; 13: 3682.
29. Mosallam RS and Haridy MF. Fracture strength of endodontically treated teeth restored with endocrown restorations with \without resin composite base materials- an in vitro study. Egypt Dent J. 019; 3:2839-48.
30. Gogna R, Jagadis S and Shashikal K. A comparative in vitro study of microleakage by a radioactive isotope and compressive strength of three nano-filled composite resin restorations. J. Conserv Dent 2011; 14: 128-31.
31. El-Farag SA, Elerian FA, El-Sherbiny AA and Abbas MH. Impact of different CAD/CAM materials on internal and marginal adaptations and fracture resistance of endocrown restorations with 3D finite element analysis. BMC Oral Health 2023; 23:421-8.
32. Jassim ZM and Majeed MA. Comparative evaluation of the fracture strength of monolithic crowns fabricated from different all ceramic CAD\CAM materials (an in vitro study). Biomed Pharmacol J. 2018; 11:1689-97.
33. Salameh Z, Ozcan M, Naffah N and Bassal H. Evaluation of the adaptation and fracture resistance of three CAD\CAM resin ceramics: an in vitro study. J. Contemp Dent Pract. 2019; 20:571-6.
34. Rocca GT, Saratti CM, Cattani- Lorente M, Feilzer AJ, Scherrer S and Krejici I. The effect of fiber reinforced cavity configuration on load bearing capacity and failure mode of endodontically treated molars restored with CAD\CAM resin composite overlay restorations. J Dent. 2015;43: 1106-15.
35. Otero CA, Donova JB, Saratti MC, Vallittu PK, Bella ED, Krejci I and Rocca TG. The influence of FRC base and bonded CAD\CAM resin composite endocrowns on fatigue behavior of cracked endodontically treated molars. J. Mech Behav Biomed Mater 2021; 121:1046-57.
36. Tiu J, Belli R and Lohbauer U. Thickness influence of veneering composites on fiber reinforced systems. Dent Mater 2021;37: 477-85.