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CLINICAL PERFORMANCE OF FIBER REINFORCED FRC BASE AND BONDED CAD/CAM RESIN COMPOSITE ENDOCROWNS VERSUS CONVENTIONAL LITHIUM DISILICATE ENDOCROWNS IN POSTERIOR TEETH (RANDOMIZED CLINICAL TRIAL)

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ABSTRACT

Purpose: To evaluate clinical performance of fiber reinforced composite base and bonded CAD/CAM resin composite endocrowns compared to lithium disilicate endocrowns over one year.

Methods: A total of 110 endocrowns, 55 lithium disilicate endocrowns (group I) (IPS e. max CAD) and 55 of bonded CAD/CAM resin composite endocrowns with fiber reinforced FRC base (group II) (Grandio) were used to restore endodontically treated molars. First shade selection was performed followed by cavity preparation and digital impression. Then restorations were designed, milled and checked intraorally before cementation using resin cement. The restorations were evaluated at baseline, 6 and 12 months using Modified USPHS criteria. Statistical analysis was performed with SPSS 20®, Graph Pad Prism® and Microsoft Excel 2016.

Results: Regarding fracture and marginal adaptation, all restorations in both groups had Alpha score (100%); at base line, after 6, and 12 months. Regarding retention, all restorations in both groups had Alpha score (100%); at base line, and after 6 months. While after 12 months, only one case had Charlie score in group I with insignificant difference between groups as P=0.32. Regarding shade match, all restorations in both groups had Alpha score (100%); at base line while after 6 months two cases were Bravo in group II with insignificant difference between groups as P=0.14. While after 12 months, three cases were Bravo in group II with insignificant difference between groups as P=0.07.

Conclusion: CAD/CAM resin composite endocrowns with fiber reinforced FRC base are just as dependable as lithium disilicate for restoring non-vital posterior teeth.

KEYWORDS: Fiber reinforced FRC base, endocrowns, CAD/CAM, Lithium disilicate.

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INTRODUCTION

Root canal treatment is the most effective therapy for pulpal and periapical diseases. [1] One of the most common challenges in restoring non-vital teeth is the risk of tooth fracture due to the loss of dentinal nutritional support of the pulp. [2] Therefore, indirect restorations like full coverage crowns with post and core are often used in the past to restore these mutilated teeth. [3] An alternative minimally invasive approach, for treatment of endodontically treated molars, is endocrowns to reinforce remaining amount of tooth structure avoiding wedging action of posts which may lead to its weakness. [4,5]. Moreover, full coverage restorations require removal of a great part of the tooth structure to provide retention for the restoration which result in further weakening of remaining tooth structure. [6] Also, post and core can lead to risk of canal perforation and catastrophic root fracture. [7]

Endocrowns are monoblock restorations that gain retention from the internal walls and the pulp chamber; thus, gaining more micro and macro mechanical retention. (8) Most studies supported that the success rate of endocrowns were superior to traditional full coverage restorations. [9,10] Moreover, endocrowns require less invasive and more simple preparation with no need of many sensitive steps such as post cementation procedures, core build-up, temporary crown and possibly crown lengthening which is time consuming and more expensive. [11]

Along with increasing demand and improvement of adhesive dentistry, dental practitioners prefer to preserve more remaining tooth structure. [12] The CAD/CAM technology and materials like ceramic and resin based composite blocks are preferred to be used nowadays avoiding inherent defects of free-hands laboratory technique and consequently improving mechanical properties. [11]

Biocompatible nanohybrid resin based endocrowns were proposed with the advantage of conservatism and easy repair in the oral cavity.[13] Some studies preferred composite blocks for restoration of endodontically treated molars over ceramic blocks due to their association with shock absorbing properties. [14]

Fiber reinforced composite (FRC) was used for non-vital teeth in the form of a thin net of randomly bi-directional/woven fibers. It is positioned either as a base in the floor of the cavity or incorporated inside the restoration. Also, FRCs are used to reinforce core build-up materials due to its crack deviating property and mechanical properties improvement; hence, preventing failure of endocrown restorations. [15]

Consequently, the aim of this trial was to evaluate the clinical performance of fiber reinforced composite base and bonded CAD/CAM resin composite endocrowns compared to lithium disilicate endocrowns over one year.

The null hypothesis of this trial was that there will be no significant difference between fiber reinforced composite base and bonded CAD/CAM resin composite endocrowns and lithium disilicate endocrowns over one year in terms of fracture, marginal adaptation, retention, and shade matching.

MATERIALS AND METHODS

Trial design and settings

This trial was registered on clinical trials. gov (NCT06348979) and was conducted in Fixed prosthodontics clinic in Newgiza University from January 2022 to December 2022. The trial was revised and accepted by the Ethical Committee of Faculty of Dentistry at Cairo University (171021). All participants were informed about the aim and all the procedures of the trial and signed informed consent for acceptance.

Eligibility criteria

Eligible patients were with age range from 18 to 55 years old, with good oral hygiene and

endodontically treated molars having no periapical pathosis. The molars should have enough remaining tooth structure: three remaining walls at least with 1.5 mm thickness and supragingival margin. Also, the teeth should be completely erupted with healthy periodontium, proper contact, and in favorable occlusion. Medically compromised patients or patients with parafunctional habits were omitted from the trial.

Sample size calculation

In order to apply a statistical test of the null hypothesis—that there is no difference in clinical performance between the tested groups—a power analysis was created with sufficient power. Using a beta of (0.2), or power=80%, and an alpha level of (0.05), the effect size (W) of (0.302) was determined using data from a prior study [16]. With 44 cases in each group, a total of 88 cases was the anticipated sample size (n). To account for potential dropouts during follow-up intervals, the sample size was raised by 25% to total 110 cases (i.e., n=55 per group). PASS 15 was used to calculate the sample size. [17]

Randomization

The randomization was done using an automated sequence generator (https://www.random.org/) into two groups: lithium disilicate endocrowns (group I) and bonded CAD/CAM resin composite endocrowns with fiber reinforced FRC base (group II). Allocation ratio was 1:1.

Allocation concealments and implementation

Each member of each group had a number written on a white piece of paper using blue ink. The paper was pleated, tightly sealed, and kept in a secure place until the treatment was performed.

Blinding

This trial is a triple-blind (assessors, patients, and statistician) randomized clinical trial.

Restorative treatment

All the clinical procedures were done by the same operator to avoid any variations. Before starting the restorative treatment, each participant received scaling and polishing to remove any stain, plaque, or calculus before shade selection. Then, Vitapan's 3D master shade guide (VITA, Zahnfabrik, Germany) had been used to select the shade by matching the shade of the adjacent teeth under color corrected light (Smile Lite, Smile Line, Switzerland) and daylight at noon. [18]

Any previous restoration was removed then a wheel diamond stone was used for occlusal reduction of 1.5 - 2 mm, performing butt margin design with minimum width 1.5- 2 mm and cavity depth 3 mm at least. After that, immediate dentin seal was performed to all dentinal walls and pulpal floor using universal bonding agent (Futurabond U, Voco, Germany). Cavity optimization with Flowable composite was applied in pulpal floor and in the axial walls for blocking any undercut to avoid weakening of the remaining tooth structure. For group I: conventional flowable composite (Te-Econom, Ivoclar Vivadent) was used while for group II: fiber reinforced flowable resin composite (FRC) was used, then light cured for 20 seconds (>700 mW/cm^2) using LED light curing device (LED.F, Woodpecker, China). Digital impression was taken using an intraoral scanner (Medit i500, Medit, Korea) followed by Exocad software for designing of the endocrowns. A five-axis milling machine (Arum 400 milling machine, Arum Gmbh, Germany) was used for milling of the restorations from IPS e.max CAD for group I or Voco Grandio for group II. [18]

First, endocrown was examined for marginal adaptation, interproximal and occlusal contacts inside patient mouth before bonding. After that, a rubber dam was used for isolation of the teeth then 37% phosphoric acid etching gel (Gel S, Coltene, Switzerland) was applied into enamel margins of

the prepared cavity for 15 seconds, followed by rinsing for 30 seconds and air dried gently. A coat of Universal adhesive bond was applied into the cavity, gently air dried for 5 seconds, and light cured for 20 seconds. [19]

Group I: 9.5% hydrofluoric acid was used for 20 seconds to etch the fitting surface of the endocrown (IPS e. max CAD; CEREC Ivoclar Vivadent, Liechtenstein), after which it was rinsed with water and allowed to air dry. Application of the silane coupling agent was next, and it was left to air dry for 60 seconds. On the other hand, for group II: the fitting surface of the restoration (Grandio, VOCO GmbH, Cuxhaven, Germany) was roughened and cleaned by intraoral sandblaster (Aquacare, Velopex, UK) with aluminum oxide particles of size 50 μm. Then, the restoration was placed for 4 minutes in ultrasonic cleaning device with distilled water. After that, gentle air drying of the fitting surface was performed and one coat of silane coupling agent (Ceramic bond, Voco, Germany) was applied for 60 seconds then allowed to air dry according to the manufacturer's instructions.

A dual-cured self-adhesive resin cement (Bifix QM, Voco, Germany) was applied to the fitting surface of the endocrown and inside the cavity, then the restoration was placed carefully into the cavity and pressed by finger pressure gently against the occlusal surface of restoration. Tack cure was done for 3 seconds (>700 mW/cm^2) using LED light curing device to remove the excess cement by using probe and dental floss. Afterwards, curing was completed for 40 seconds at each surface. If there were any occlusal interferences, it was eliminated. Finishing and polishing were accomplished for obtaining a lustrous surface and proper esthetic appearance **Figure (1)**. [18]

Assessors' calibration for clinical evaluation

For standardization of the shade selection process, two qualified staff members did the evaluation of the shade in comparison with adjacent teeth, using color corrected light and daylight at noon, under the regulations of the Modified United States Public Health Service (USPHS) criteria. Evaluation was performed at base line, 6 months, and 12 months. If there was any conflict, it was resolved by discussion. [18]

Statistical analysis

Frequency and percentage were used to present all qualitative data. Every comparison made use of the Chi square test. Microsoft Excel 2016, Graph Pad Prism, and SPSS 20® were used for statistical analysis.

Fig. (1): Resin composite endocrowns with fiber reinforced FRC base after cementation

RESULTS

Demographic data

In group I, male revealed (49.1%), but female revealed (50.9%). While in group II Male revealed (50.9%), but female revealed (49.1%). Using the Chi square test, the comparison between the two groups showed insignificant difference, with P=0.58 in **Table (1).**

Fifty participants from group II and forty-eight participants from group I finished their follow-up of the trial. **Table (2)**

TABLE (1) Frequencies (n), percentages (%) of gender distribution among both groups and comparison between them using Chi-square test

Demographic data		Group I (Emax) **N= 55**	Group II (FRC) **N=55**	*P*-value
Gender n (%)	Male	24 (49.1)	28 (50.9)	0.58 ns
	Female	31 (50.9)	27 (49.1)	

NS: Non-significant difference as P > 0.05

Table (2): Frequency and percentages of all scores regarding fracture, marginal adaptation, retention, and shade match in group I and II at baseline, after 6 months and after 12 months

Parameter	**Follow up**	**Score**	**Group I (Emax)**		**Group II (FRC)**		**P value**	**Effect size**
			N	%	N	%		
Fracture	**Baseline**	Alpha	55	100	55	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	6 months	Alpha	50	100	48	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	12 months	Alpha	50	100	48	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
Marginal adaptation	**Baseline**	Alpha	55	100	55	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	6 months	Alpha	50	100	48	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	12 months	Alpha	50	100	48	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
Retention	**Baseline**	Alpha	55	100	55	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	6 months	Alpha	50	100	48	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	12 months	Alpha	49	98	48	100	0.97	0.32
		Bravo	0	0	0	0		
		Charlie	1	2	0	0		
Shade match	**Baseline**	Alpha	55	100	55	100	----	----
		Bravo	0	0	0	0		
		Charlie	0	0	0	0		
	6 months	Alpha	50	100	46	95.8	2.12	0.14
		Bravo	0	0	2	4.2		
		Charlie	0	0	0	0		
	12 months	Alpha	50	100	45	93.7	3.2	0.07
		Bravo	0	0	3	6.3		
		Charlie	0	0	0	0		

N: frequency %: percentage Ns: non-significant at P > 0.05

Evaluation of fracture and marginal adaptation

All restorations in both groups had Alpha score (100%); at base line, after 6, and 12 months **Figure (2)**. All the results demonstrated in **Table (2)** and **Figure (3)**.

Evaluation of retention

All restorations in both groups had Alpha score (100%); at base line, and after 6 months. While after 12 months, only 1 case showed Charlie score in group I with insignificant difference between groups as P=0.32

Evaluation of shade match

At baseline, all restoration in both groups had an Alpha score of 100%. However, 2 cases in group II after 6 months revealed Bravo scores, with a P=0.14 statistically insignificant difference between the groups. Nevertheless, 3 cases in group II after a year revealed Bravo scores, with P=0.07 indicating an insignificant difference between the groups.

Fig. (2) Resin composite endocrowns with fiber reinforced FRC base showing marginal adaptation with Alpha score.

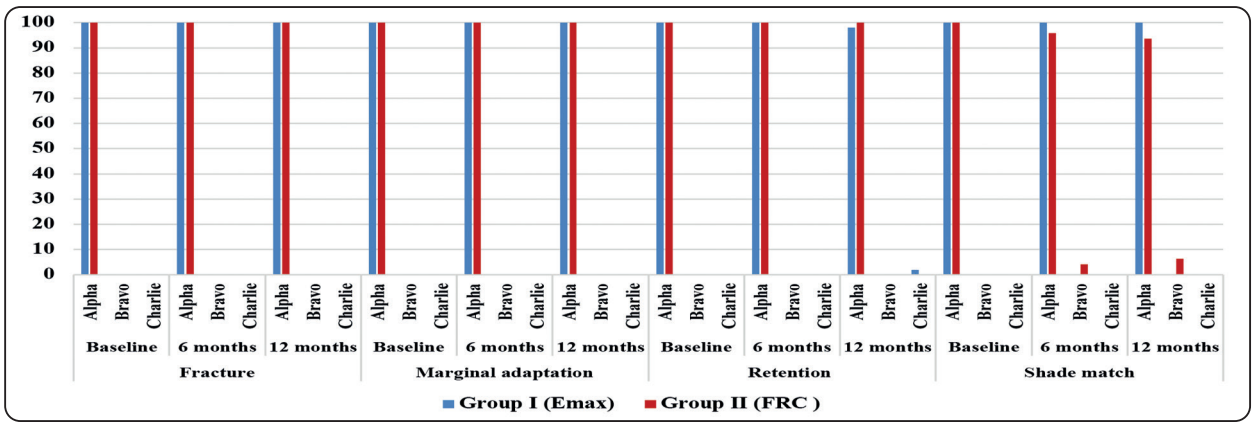

Fig. (3) Bar chart representing different scores of fracture, marginal adaptation, retention and shade matching in both groups at different intervals

DISCUSSION

In restorative dentistry, restoring teeth with endodontic treatment is a significant problem because of their compromised biomechanical properties, dehydrated dentin, and mutated collagen due to the effect of irrigation. These changes along with the loss of tooth structure have a negative impact on long term prognosis of the teeth which may increase their liability to fracture. Therefore, research recommended preservation of tooth structure with conservative preparation like endocrowns. [20] The latter include supragingival borders on peripheral enamel without radicular preparation, leading to improved bonding capability and decreased concentration of stresses at the cement/dentin interface. [8, 21, 18]

Flowable FRC composite (EverX Flow) is considered one of recent innovations in restorative

dentistry for reinforcing teeth with unique composition, characteristic and strengthening abilities. EverX Flow can be used as dentin replacement. It was considered as the flowable form of the packable FRC (ever-X Posterior) containing inorganic filler, resin matrix, and glass microfibers. Numerous studies have been carried out to evaluate the properties of the EverX flow. However, little clinical trials have been conducted for clinical assessment of the material. [22] Lithium disilicate endocrowns have high flexural strength, fracture toughness which can resist the crack propagation in addition to the improvement of bonding with natural tooth structure. All these properties allow lithium disilicate to be the gold standard of the glass ceramic restorations. [18]

In our clinical trial, we selected the shade after scaling and polishing for accurate shade matching under both color corrected light and daylight at noon to avoid metamerism. According to several studies, fracture resistance of ceramic restorations improves by increasing the occlusal thickness. [23, 24, & 19] Endocrowns with 5.5 mm thickness have twice fracture resistance compared to ceramic restorations with 1.5 mm thickness at occlusal surface. Therefore, in this clinical trial, the cavity depth was at least 3 mm pulp chamber depth, for improvement of the mechanical properties. [18]

The outcomes were evaluated following the modified USPHS criteria during follow-up visits. The drop-out of patients, who did not complete the follow-up visits, was within the 10% increased range, that was already considered in the sample size calculation.

According to our trial's findings, the hypothesis was accepted, as there was no significant difference between both groups regarding fracture, marginal adaptation, color match, and retention. This agreed with the results of ***Coşkun et al in 2020, Souza et al in 2021***, ***Hassan et al in 2023 and Elmoselhy et al in 2024*** [25, 26,24, 19] after one year follow up, which evaluated CAD/CAM ceramic and composite blocks. In contrast with ***Darwish et al in 2017 and Ibrahim et al in 2022*** [27,28] stated that resin nanocomposite CAD/CAM blocks showed better marginal adaptation than ceramic blocks. This is due to the high modulus of elasticity of ceramic restoration compared to the lower modulus of elasticity of hybrid resin composite. This contributed to the degradation of adhesive resin cement under functional loading which affected marginal adaptation of ceramic restorations.

Regarding fracture of restorations, there were no significant changes ($p > 0.05$) between both groups which was in agreement with ***Tunac et al in 2019, Souza et al in 2021*****, and** ***Elmoselhy et al in 2024.*** [29, 26, 19] They provided an explanation for their findings due to the restorations' enhanced bonding to the tooth and the CAD/CAM blocks' high mechanical qualities. This helps stress distribution by decreasing sensitivity to masticatory forces. [30] Additionally, CAD/CAM technology reduces the detrimental effects of polymerization shrinkage strains by controlling the luting resin cement's thickness. [31] In contrast to ***Borgia et al in 2016*** **and Wang** ***et al in 2020*** [32 &23] who discovered significant difference between resin based and ceramic endocrowns in favor of Grandio hybrid nanoceramic blocks that contained 86% inorganic fillers in a polymer matrix which improved the fracture resistance. The monoblock structure of hybrid resin composite endocrowns dissipated more energy under loading because it has dentin like modulus of elasticity.

In this trial, no significant difference was found after application of FRC as a base under nanohybrid resin composite (Grandio) as agreed with the results of ***Fennis et al in 2005, Rocca et al in 2015, Otero et al in 2021 and Tiu et al in 2021*** [33, 11, 20, 34] that stated that FRC base layer was not believed to have a beneficial effect on prevention of crack propagation. In contrast with ***Garoushi et al in 2006***, ***Keulemans et al in 2009 and Dere et***

al in 2010 [35, 36, 37] who proposed that application of FRC in larger amount or longer bundles increase fracture resistance. Also, the bidirectional pattern of fiber reinforcement was better than multidirectional fibers, getting stiffer network of fibers.[35] Moreover, it was proved that the fiber reinforcement positively influenced the manner of failure and the spread of cracks, increasing the likelihood of repairability. [20]

Regarding marginal adaptation of restorations, there were no significant changes ($p > 0.05$) between both groups in accordance with ***Fasbinder et al in 2005 and Hassan et al in 2023*** [38,24] after one year follow up. However, composite CAD/CAM endocrowns showed better marginal adaptation due to advantage of resin nanofillers incorporated that showed lower crack propagation and more fracture resistance than CAD/CAM ceramic blocks according to ***Pfeilschifter et al in 2018*** and ***Colombo et al in 2019*** [39, 40]***.*** On the other hand, ***Yildirim et al in 2017*** [41] found reduced marginal adaption for the hybrid ceramic restorations compared to glass-ceramics (IPS e.max) in an in-vitro study. Furthermore, other variables such as the inherent characteristics of the CAD/CAM system and the milling machine speed may also affect the results.[42]

Regarding retention of restorations, there were no significant changes ($p>0.05$) between both groups as consenting to ***Wang et al in 2020 and Hassan et al in 2023*** [23,24]***.*** In this trial, one debonded e.max restoration was found after one year due to improper surface treatment of the internal surface of lithium disilicate which may lead to poor bonding and subsequent debonding. The luting cement is an important component that has a big impact on long-term performance of endocrowns. ***Hassan et al in 2023*** [24] found two debonded e.max restorations after one year follow up due to failure to deliver the restoration in a single visit which may increase the possibility of tooth contamination and subsequently affecting the retention of the restorations.[43]

Regarding shade match of restorations, there were no significant changes ($p > 0.05$) between both groups in accordane with ***Hassan et al in 2023.*** [24] In this trial, there were notable color shift after six months in two patients and in three patients after 12 months, observed in the Grandio group that can be the result of glazing loss. Staining of the hybrid ceramic blocks is used to improve the restoration's cosmetic appeal, giving the patient a more natural looking appearance and improve the number of satisfied patients along the course of treatment. Applying glaze is advised to shield the applied stains.[44] In hybrid ceramics, staining and glazing are two distinct procedures. [45] While in lithium disilicate ceramics, stains can be applied during high temperatures of firing process. The loss of glazing in Grandio group might be due to acidic beverages leading to loss of color match and holding more stains by time.[45] In IPS e.max group, optimum color match was found according to this trial. ***De Pinho-Barcellos et al in 2022*** claimed in an in-vitro study that glazing and staining could enhance bacterial adhesion and surface wear in addition to decreasing biaxial flexural strength of glass ceramics [46].

Limitations of this trial were short follow-up time and clinical evaluation of other restorative materials. Finally, both restorations show promising results, but many variables affect clinicians' decision. Material selection, preparation design, and individual patient factors play crucial roles in achieving successful outcomes.

CONCLUSION

Within the limitations of this trial, the subsequent conclusion can be withdrawn:

Bonded CAD/CAM resin composite endocrowns with fiber reinforced FRC base are just as dependable as lithium disilicate endocrowns for restoration of endodontically treated posterior teeth.

CLINICAL IMPLICATION

For restoration of endodontic treated molars, endocrowns fabricated from lithium disilicate and bonded CAD/CAM resin composite endocrowns with fiber reinforced FRC base could be used as restorations with good prognosis.

CLINICAL RECOMMENDATION

Further long-term studies along with various restorative materials are recommended.

CONFLICT OF INTEREST

There are no disclosed conflicts of interest concerning the authors.

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