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FRACTURE RESISTANCE OF ENDOCROWNS FABRICATED FROM THREE DIFFERENT PRESSABLE CERAMIC MATERIALS

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ABSTRACT

INTRODUCTION: The selection of fabrication materials plays a crucial role in the clinical outcome of endocrown restorations. However, a notable gap exists in understanding the biomechanical implications of certain materials for endocrown restorations.
Purpose: The aim of the study was to evaluate and compare the fracture resistance of endocrowns fabricated from three different pressable ceramic materials.
MATERIALS AND METHODS: Extracted non carious mandibular first molar was embedded in acrylic resin cylinder then prepared to receive an endocrown. Thirty positive replica of epoxy resin dies were used. The dies were randomly divided into three groups (n=10): restored using zirconia reinforced lithium disilicate and zirconia reinforced lithium silicate and lithium disilicate. After cementation, the fabricated endocrowns were exposed to thermal and cyclic loading corresponding to six months of clinical service to simulate oral cavity conditions. Each endocrown was tested under a compressive load using a universal testing machine to evaluate the fracture resistance. Failure mode analysis was evaluated visually. Data was collected and analyzed using Kruskal-Wallis test and Dunn- Sidak test.
RESULTS: The highest mean and median Fracture Resistance (N) were observed in the e-max group (2289.32 and 2178.36 respectively), followed by the Celtra press group (2236.03 and 2093.52 respectively). The lowest Fracture resistance was observed in Vita Ambria group with a mean of 2014.40 and a median 1908.59. However, all values were within the acceptable clinical range. (p=0.155).
CONCLUSION: No significant difference in fracture resistance among endocrowns fabricated from lithium disilicate ceramic, zirconia-reinforced lithium silicate, and zirconia-reinforced lithium disilicate.
KEYWORDS: Endodontically treated teeth, endocrowns, fracture resistance, dental ceramics, epoxy resin.
RUNNING TITLE: Fracture resistance of endocrown using pressable materials.

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INTRODUCTION

Endodontically treated teeth (ETT) demonstrate an increased susceptibility to biomechanical failure when compared to vital teeth, posing a prevalent challenge in restorative dentistry due to the incidence of fractures in teeth (1). Preservation of the quality and structural integrity of the remaining tooth is crucial, as it serves as the essential foundation needed for tooth restoration and plays a pivotal role in determining the structural integrity of the rehabilitated tooth (2).

The main factor contributing to the decline in fracture resistance and stiffness in endodontically treated teeth (ETT) is the compromised structural integrity induced by factors such as trauma, caries, and extensive cavity preparation, rather than dehydration or alterations in the dentin physical properties (3).

The real breakthrough in restoring endodontically treated teeth was through the introduction of adhesive techniques, which was made possible by the advancement of efficient dentin adhesives, as it enhances the fracture resistance and retention of such restorations (4). An endocrown is a conservative technique for restoring teeth, using the pulp chamber for retention purposes (5). Pissis described the monoblock technique in 1995, laid the foundation for the development of the endocrown restoration (6). The concept of the endocrown was initially introduced by Bindl and Mormann in 1999. They described a monolithic ceramic restoration fixed within the pulp chamber, utilizing the micromechanical retention properties offered by the walls of the pulp chamber (5).

Endocrowns have been proven to be a dependable treatment option in restoring mutilated root-filled teeth, with survival rate exceeding 90% over a decade (7).

A systematic review by Thomas et al., (8) reported the success rate of endocrowns on molars from 72.73% to 99.57% over a period of 3 to 19 years.

In laboratory studies, research findings suggest that teeth restored with endocrowns demonstrate similar, and sometimes even superior, fracture resistance in comparison to those with conventional crowns or post and core restorations (2-5).

The fabrication of endocrowns, similar to conventional ceramic crowns, often involves either utilizing CAD-CAM milling techniques on a ceramic block or through a pressing process (9). The effectiveness and resilience of endocrown restorations are greatly affected by the accuracy of the tooth preparation design and the appropriate selection of ceramic material (10).

Commonly used pressable ceramics materials include lithium disilicate glass-ceramics (11) such as e.max press (Ivoclar Vivadent, Liechenstein) which are a notable material in dentistry, particularly for their high esthetic quality and effective bonding properties when used with adhesive cementation, as they are derived from glass-ceramic materials. Despite these advantages, lithium disilicate ceramics have limitations when applied in the restoration of endodontically treated molars. Their compressive strength, recorded at 448 MPa (±68 MPa), can make them susceptible to cracks or even catastrophic fractures under stress. As a result, a material with greater compressive strength, such as zirconia-reinforced lithium disilicate, has been proposed to better withstand the forces of mastication (12). The recently introduced zirconia-reinforced lithium disilicate press (Vita Ambria) (VITA Zahnfabrik, Germany) which is available as pressable pellet with very high stability (> 500 MPa) to be used for the fabrication of various dental restorations including inlays, onlays, partial veneer crowns, full veneer crowns, three-units bridges up to the second premolars and laminate veneers (13).

Among dental ceramic materials available nowadays is zirconia reinforced lithium silicate such as Celtra press (DENTSPLY DeguDent GmbH, USA) is a new material that can deliver the highest level of esthetics mimicking natural teeth based on having an amazing chameleon effect, it contains 10% zirconium oxide as a nucleating agent dissolved in the glass matrix. Celtra press exhibits high strength, estimated to be around 500 MPa, and demonstrates outstanding flow characteristics during the pressing procedure (14).

The fracture resistance of ceramic restorations can be affected by several factors, such as the characteristics of the supporting structure (15), including its elastic modulus (16) and bond strength. It is crucial to evaluate and compare the fracture resistance of endocrowns fabricated from these materials, according to the biomechanical behavior of these ceramic materials.

The aim of this study was to evaluate and compare the fracture resistance of endocrown restorations fabricated from three different pressable ceramic materials: Lithium disilicate, zirconia reinforced lithium silicate and zirconia-reinforced lithium disilicate.

The null hypothesis proposed that there would be no significant variation in the fracture resistance of endocrowns fabricated from the three different pressable ceramic materials.

MATERIAL AND METHODS

Study setting

The samples preparation and examination were held in the Conservative Dentistry Department laboratory at the Faculty of Dentistry, Alexandria University.

Sample size estimation

Sample size was estimated assuming a power of 80% to detect a standardized effect size in the fracture resistance (d=0.774) (large-sized standardized effect size), and level of significance 95% (α=0.05), the minimum required sample size was found to be 10 teeth per group (number of groups=3) (Total sample size=30 teeth). Any sample withdraws from the study will be replaced to maintain the sample size. The sample size was calculated using GPower version 3.1.9.2

1. Tooth selection

Natural teeth used in current study were collected from Department of oral surgery, Alexandria University after obtaining ethical approval form institutional review board, Faculty of Dentistry Alexandria University. Freshly mandibular first molar was extracted for periodontal or prosthodontic therapeutic reasons, stored in distilled water until the preparation for the study. The inclusion criteria for the sample tooth were lack of caries, restoration, cracks, or previous endodontic treatment. The institutional ethical review board had approved this study protocol (SRC/ ETH/2018-19/089).

2. Preparation of the master die for laboratory study

An extracted, non-carious mandibular first molar was selected and embedded in an acrylic resin block, exposing the crown and 2 mm apical to the cemento-enamel junction. The tooth was prepared with the following coronal features: a 90˚ butt joint preparation design with a 2 mm occlusal reduction. **(Fig. 1)**. Using a modified dental surveyor, a custom-made copper attachment was designed to be fixed to the vertical handle of the surveyor to control the tilt of high-speed handpiece and control depth and taper degree. For standardization of the preparation depth in different areas, depth orientation grooves were performed using inlay preparation stone #6845 (Komet, Trophagener, Germany) to provide 2 mm occlusal reduction, then long tapered round end #5850 (Komet, Trophagener, Germany) was used for cusp reduction, finally inlay finishing diamond #8845 (Komet, Trophagener, Germany) stone was used to smooth and finish the preparation. The average pulp chamber height (retention area) post reduction was 5mm. To duplicate the samples: a mold of the prepared tooth was made using additional silicone duplicating material. Epoxy resin material (RenCast® Epoxy Casting Resin, CH-4057 Basel, Switzerland) was poured into the mold to duplicate the master die **(Fig. 2)**. The mold was used several times to obtain thirty positive replicas of the master die. Epoxy dies were randomly distributed into three groups according to the three different pressable ceramic materials.

3. Grouping

The thirty epoxy dies were randomly divided into three groups (n=10), according to the material used:

1. Group I (IPS E-Max press lithium disilicate).
2. Group II (Celtra press Zirconia reinforced lithium silicate).
3. Group III (Vita Ambria Zirconia reinforced lithium disilicate).

4. Fabrication of the endocrown

Scanning of the epoxy dies using intraoral scanner by Cerec Omnicam Scanner (Sirona Dental Systems, Germany). The thirty digital scans for the epoxy dies were used to design thirty wax specimens using standardized CAD software. The designed endocrown restorations were milled from wax using 5-axis milling machine (Ceramill Motion 2; Amann Girrbach AG) **(Fig. 3)**. Using heat pressing technique to fabricate the endocrown, wax specimens were then sprued to base former and invested according to manufacturer's instructions. Each three wax pattern were attached to the ring base through their sprues which were diverged away from each other with equal distance to avoid contacts during pressing process. Investing was carried out with a phosphate-bonded investment material (IPS PressVest; Ivoclar Vivadent USA). The investment material was mixed using a vacuum mixer for 30 seconds to obtain a homogenous mix, then poured slowly into the ring. Mixing of investment was carried under vacuum and poured under vibration to prevent formation of air bubbles. After setting of the investment material, the ring base was removed with turning movement, then carefully pushing the investment ring out of the silicone ring then placed in the pre heating (burn-out) furnace using investment tongs and heated for 850° C for 30 minutes to ensure complete burn out of wax without leaving any residue After completing preheating cycle, the investment ring was removed from the burn-out furnace then the ceramic ingots were inserted into the hot investment mold. The pressing cycle was done using the appropriate furnace type for each material type and the appropriate program was selected according to the manufacturer's instructions (Programat EP 3010, Ivoclar Vivadent, USA) was used for IPS-E-max press and (VITA Vacumat 6000 MP; VITA Zahnfabrik, Germany) was used for both Celtra press and Vita ambria **(Table 1)**. After pressing, the investment molds were removed from the furnace for air cooling. The pressed specimens were carefully divested and separated aided using airborne particle abrasion device with 100 microns polishing beads at 4 Bars for gross divestment. The sprues were cut using diamond disks. The final ceramic restorations were finished and polished to obtain smooth surface.

5. Surface treatment and cementation

All fabricated endocrowns were cemented on their respective epoxy resin dies using dual cured, self-adhesive resin cement under static load**.** The fitting surface of each endocrown was cleaned with a piece of cotton soaked in alcohol, then rinsed with water spray and dried by air. Etched with 9.5% hydrofluoric acid gel (Porcelain Etchant, BISCO, USA) for 60 seconds then rinsed thoroughly with water spray and air dried. Applying one layer of silane coupling agent (Porcelain Primer, BISCO, USA) for 60 seconds then dried by air without rinsing or curing. Etching of the prepared surfaces by 35% phosphoric acid gel (Bisco acid etch, BISCO, USA) for 30 seconds then rinsing with water spray and dried by air. Bonding agent (Bisco universal bond, BISCO, USA) was applied on the prepared surface, then dried by air and light cured for 10 seconds according to the manufacturer's instructions. Dual cured resin cement (Duo-Link, BISCO, USA) was applied in the prepared surface of epoxy resin die and the endocrown was seated gently with finger pressure on their respective resin dies. Then complete curing under static load device with vertical load of 5kg for 10 mins and light cured for 20 seconds on each surface using SDI plus light-curing unit (SDI, Australia).

6. Aging of the specimens

The fabricated specimens were exposed to 600 thermal cycles through mechanical transfer 5- 55˚C water baths with a dwell time of one minute in each bath, with a 30-second relaxation period in air between the two baths (3). During load cycling, the specimens were exposed to 120,000 chewing cycles with a repeated impact load of up to 49 N (5 kg) at a frequency of 1.7 Hz in each group. The mechanical load was applied vertically onto the center of the occlusal surface of each endocrown using a 6mm diameter steel ball antagonist. These aging procedures were intended to simulate six months of clinical serviceThese aging procedures were intended to simulate six months of clinical service (17, 18).

7. Assessment of fracture resistance

All epoxy resin dies were mounted individually in a vertical position on a universal testing machine. The samples were affixed to lower fixed compartment of the machine by tightening screw. Each endocrown was tested under a compressive load under a universal testing machine to evaluate the fracture resistance for each specimen. The load was administered using a custom-made load applicator, consisting of a steel rod with a spherical tip measuring 6mm in diameter. This applicator was positioned at the center of the occlusal surface and affixed to the upper movable compartment of the machine. The load was continuously applied until the specimen fractured (19). The specimens underwent static compression loading until fracture at a crosshead speed of 1 mm/min.

Mode of failure

Evaluation the mode of failure of the specimens visually. According to Bruke classification restorations failure were classified as (20):

1- Class I: Minimal fracture or crack in crown
2- Class II: Less than half of the crown lost
3- Class III: Crown fracture though midline; half of crown displaced or lost
4- Class IV: More than half of the crown lost
5- Class V: Severe fracture of tooth and/or crown

Statistical analysis

Data were gathered and input into the computer for statistical analysis using SPSS (Statistical Package for the Social Sciences) software, version 25. The Kolmogorov-Smirnov test for normality indicated a significant deviation in the distribution of the variables, necessitating the use of non-parametric statistical methods. Mean, median, and standard deviation were calculated for all variables. The Kruskal-Wallis test was utilized to compare multiple independent subgroups that were not normally distributed. Post-hoc pairwise comparisons were performed using the Dunn-Sidak test for multiple comparisons when the Kruskal-Wallis test yielded significance. P value was adjusted using Bonferroni correction method. The association between qualitative variables was assessed using Pearson's Chi-square test, with Monte Carlo corrections applied as needed. Statistical significance was evaluated at p value <.05.

RESULTS

This study evaluated the fracture resistance of endocrown restorations fabricated from three different pressable ceramic materials: Lithium disilicate (IPS-Emax press), zirconia reinforced lithium silicate and zirconia-reinforced lithium disilicate.

Fracture resistance

The fracture resistance in all groups ranged from 1564.97 to 3792.31. The highest mean and median Fracture Resistance (N) were observed in the e-max group (2289.32 and 2178.36 respectively), followed by the Celtra press group (2236.03 and 2093.52 respectively). The lowest Fracture resistance was observed in Vita Ambria group with a mean of 2014.40 and a median 1908.59. The data was not normally distributed, and using the Kruskal Wallis significance test, no statistical significance was observed among the groups (p=0.155) **(Table 2)**.

Table (1): Heat pressing parameters of the three heat pressed ceramics

Pressing Parameters	IPS E-Max press	Celtra press	Vita Ambria
Stand-by temperature	700 °C	700 °C	700 °C
Temperature increase/min	60°C/min	40°C/min	50°C/min
Pressing temperature	925°C	860°C	880°C
Holding time	25 mins	30 mins	25 mins

Table (2): The Fracture Resistance (N) among the three studied groups

Fracture Resistance (N)	Group E-max (n=10)	Celtra press (n=10)	Vita Ambria (n=10)
- Min-Max	1698.95-3792.31	1685.85-3205.18	1564.97-3229.97
- Mean ± SD	2289.32±586.28	2236.03±457.34	2014.40±469.75
- 95% CI of the mean	1869.92-2708.71	1908.87-2563.18	1678.36-2350.44
- Median	2178.36	2093.52	1908.59
- 95% CI of the median	1988.16-2366.74	1956.68-2410.73	1710.94-2158.47
25th Percentile – 75th Percentile Kruskal-Wallis Test of Significance *p*-value	$H_{(df=2)}$ =3.724 *p*=.155 NS		

n: number of teeth
Min-Max: Minimum to Maximum
SD: Standard deviation
CI: Confidence interval

Failure mode analysis

By visual inspection according to Bruke classification (20), the most failure modes observed within the specimens were type I, IV and V in all tested groups (Chi-Square test=c2 (df=4)=1.952). The most failure modes observed within the specimens were class I (23.33%), IV (46.67%) and V (30.00%). Most of the class I and class V failures were found in Celtra Press specimens. While the majority of class IV failures were observed among Vita Ambria specimens. Since only the restorations and not the underlying tooth structure are damaged, classes I and IV are regarded as favorable failures. Most failures among the test groups were favorable fractures of only the restorations. **(Figs. 4,5,6)**.

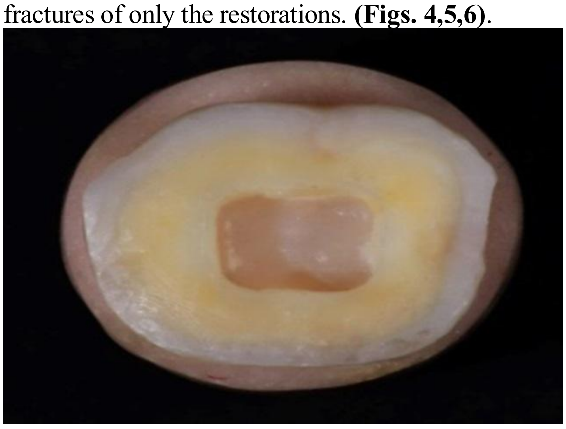

Figure (1): Tooth preparation.

Figure (2): Epoxy resin die.

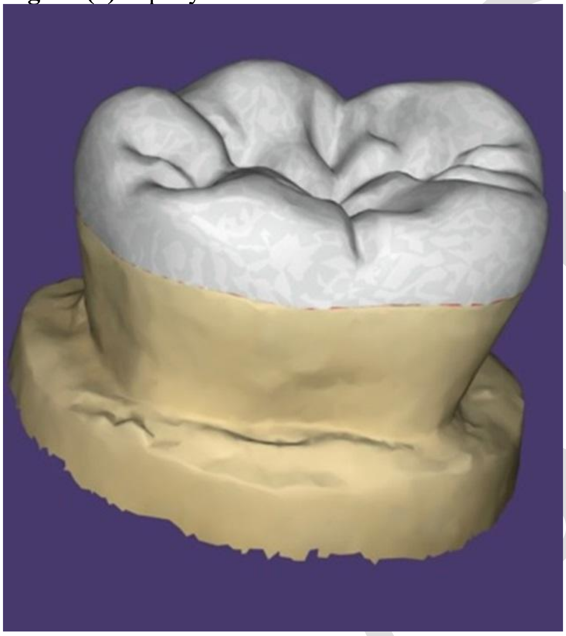

Figure (3): Design of endocrown.

Figure (4): Class I mode of failure (20%) from group I.

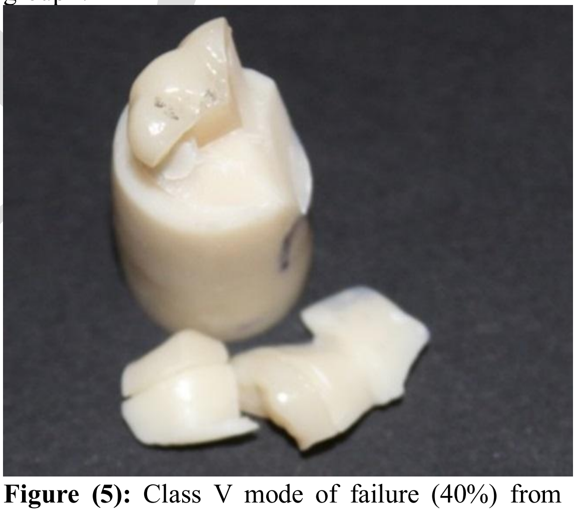

Figure (5): Class V mode of failure (40%) from group II.

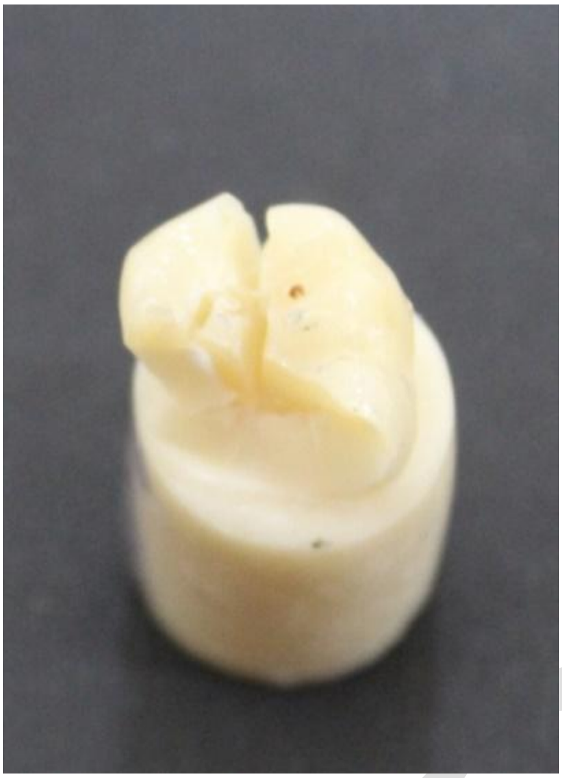

Figure (6): Class IV mode of failure (60%) from group III.

DISCUSSION

In restoring endodontically treated teeth, the selection of restoration type and material varies according to the remaining tooth structure and functional requirement. Helfer et al. (21), proposed the decline in root-filled teeth strength was linked to the loss of moisture. Maintaining a minimum of five millimeters of coronal tooth structure post-root canal treatment is recommended to ensure longevity under function (22).

The purpose of the study was to evaluate and compare the fracture resistance of endocrown restorations fabricated from three different pressable ceramic materials. In the current study, the use of epoxy resin limits the anatomical variations introduced by the use of natural teeth, and the possibility of presence of subclinical cracks compromising standardization. The endocrowns in this study were cemented and tested over epoxy resin dies to obtain fracture resistance values near to those cemented on dentin. Epoxy resin has a modulus of elasticity (12.9 GPA) which is similar to the reported modulus of elasticity of human dentin (14.7 GPA)(23).

To fabricate heat-pressed endocrowns, intra oral scanner was used to scan the epoxy resin dies instead of regular final impression; thus eliminating the need for stone die fabrication for better accuracy.

The success rate of endocrowns varies across different studies due to several factors such as the design of the preparation, the choice of materials, and the adhesive protocol. In the study conducted by de Kuijper et al., (24) to assess the mechanical behavior of mutilated root-filled molars restored using different restorative approaches, there was no statistically significant difference in the fracture resistance among lithium disilicate crown (3217±1052 N), lithium disilicate crown with fiber post (2697±665 N) and endocrown groups (2425±993 N).

The design of endocrowns may differ in terms of the degree of occlusal reduction, the divergence angle of the pulp chamber walls, the presence of ferrule and the width of the butt joint margins (25). Dartora et al., (26) explored the effect of intracoronal depth of teeth restored with endocrowns on fracture resistance of molar. They found that extensions of 3 mm and 5 mm in the chamber provided the greatest fracture resistance, while a 1 mm extension offered the least. In the current study a depth of 5 mm was used to ensure higher fracture resistance as recommended by previous study.

Lin et al. (27) found that an occlusal thickness of 4 mm demonstrated greater fracture resistance than a thickness of 2 mm in both lithium disilicate and zirconia. Therefore, in the current study a depth of 2 mm was used to ensure higher fracture resistance as recommended by previous study.

Regarding fracture resistance of endocrowns in the present study, the null hypothesis was accepted. There was no significant difference in the fracture resistance of endocrowns fabricated from the three pressable ceramic materials used. Even though there was no statistical significance, the mean values of the Vita Ambria (2014.40±469.75 N) were reported to be lowest among the three groups, while the E-max press group (2289.32±586.28N) had comparable fracture resistance to the Celta press group (2236.03±457.34 N).

All tested samples showed fracture resistance that surpassed the mean occlusal force which can vary from 445 N to 800 N (28).

The results of the mean fracture resistance values of e-max press and Celtra press showed no statistically significant difference. This was in accordance with Apel et al (29), who concluded that the addition of zirconia to glass matrix of lithium disilicate did not increase the flexural strength owing to the increase in viscosity due to ZrO_2 content and the accompanied decrease in crystal growth.

Lithium disilicate provides restorations that not only possess high mechanical strength but also have an aesthetic appeal that closely matches that of natural tooth enamel (30). IPS e.max press is currently considered as a gold standard reference for comparisons in many in vitro studies (31). When bonded to the prepared tooth, lithium disilicate demonstrates a monolithic strength adequate for posterior single tooth restoration. It is comprised of a unique crystalline structure, which gives the material strength and uncompromised esthetics (31). Celtra press is another innovative advancement in glass ceramic materials containing

10% zirconia providing high mean flexural strength in addition to its high glass Content (14).

Zirconia-reinforced lithium silicates (LSZ) were introduced as a novel glass-ceramic material that incorporated approximately 10%wt zirconia. This composition provided higher mechanical properties along with improved esthetics. Despite the purpose of incorporating zirconia particles for the reinforcement of the ceramic structure through crack interruption (30), the relatively larger crystals of lithium disilicates have been proved to effectively bridge cracks due to the presence of more convoluted crack paths at the microstructural level when compared to LSZ (14). The addition of ZrO_2 as a nucleating agent facilitated volume crystallization in the glass, while inhibiting crystal growth. As a result, the pressed samples contained smaller lithium silicate crystalline phases compared to glass-ceramics without ZrO_2. These smaller crystals negatively impacted the mechanical properties of the glass-ceramic (14).

To eliminate variables during the bonding process, strict adherence to the bonding techniques recommended by the manufacturer for the ceramic material was maintained.

A heat pressed zirconia reinforced lithium disilicate glass ceramic material (VITA Ambria) has been recently introduced. The manufacturer (VITA Zahnfabrik) claims that subjecting this material to thermal tempering (at 800^{o}C), would improve its flexural strength form 400 MPa to 550 MPa (13).

The glass ceramic fabrication method in this study was done using the heat-pressing technique. Several studies reported the advantageous use of the heat-pressing technique as it decreases the porosities and heterogeneousness in the ceramic microstructure by inhibiting extensive grain growth or secondary crystallization (23, 32).

A study comparing the failure loads of IPS e.max press and IPS e.max CAD endocrowns reported heat-pressed lithium disilicate endocrown to be superior. Regardless of the fabrication method, all specimens had higher failure loads than the maximum bite force of humans (33).

In the literature, there was only one study that compared the fracture resistance of IPS e.max press to vita ambria. The study was conducted by ElHamid et al., (34) who concluded endocrowns fabricated from vita ambria had a superior fracture resistance to endocrowns fabricated from IPS e.max. These findings are inconsistent with the current investigation. However, the endocrowns in the investigation done by ElHamid et al., were not exposed to thermomechanical aging.

Another study by Ghajghouj and Tasar (35) reported the mean fracture resistance of zirconia reinforced lithium silicate glass to be higher than lithium disilicate glass, however, also in this study, no chewing -simulation test was performed. In the present study the endocrowns were exposed to 120,000 chewing cycles of a repeated impact load up to 49 N (5 kg) at a frequency of 1.7Hz.

Specimen aging is of the utmost importance in studying fracture resistance as the repetitive stresses were shown to cause subcritical crack growth in the glass ceramic material (36). A study investigated the effect of thermocycling on the microstructure of feldspathic, lithium disilicate and zirconia reinforced lithium silicate after being subjected to 10,000 cycles. The findings revealed zirconia reinforced lithium silicate to be the most affected by thermocycling while lithium disilicate was the least affected (37).

Dartora et al., (38) reported that thermomechanical loading applied prior to the fracture resistance testing contributed to instability in the phases of the zirconium oxide-reinforced lithium silicate. This led to an upsurge in the local residual stresses that eased during cooling forming microcracks.

Although all failure modes were obtained in the present study, The most failure modes observed within the specimens were class I (23.33%) which are characterized as Minimal fracture or crack in crown, IV (46.67%) which are characterized as more than half of the crown lost and V (30.00%) which are characterized as severe fracture of tooth and/or crown. Most of the class I and class V failures were found in Celtra Press specimens. While the majority of class IV failures were observed among Vita Ambria specimens. Since only the restorations and not the underlying tooth structure are damaged, classes I and IV are regarded as favorable failures. Most failures among the test groups were favorable fractures of only the restorations. The differences in the fracture mode results may be related to the elastic moduli of ceramics. It is desirable for the elastic modulus of dentin and the chosen material to be similar so that proper stress distribution may be achieved (39). Hayes et al. (40) suggest that the design of the retention cavity, specifically when it extends 4 mm into the pulp chamber, may contribute to failure modes. Their research indicates that endocrowns with a deeper pulp chamber depth (4 mm) are more prone to irreparable failure compared to those with a shallower depth (2 mm). In cases where the pulp chambers are partially built up with resin composite, leaving only 2 mm for lithium disilicate (LDS) endocrowns, the risk of failure is reduced.

Since this study is an in-vitro study, various clinical scenarios were not mirrored such as the presence of saliva and the dynamic forces that govern the oral environment. The limitations of this study include the small sample size, the disregard of natural teeth anatomical variations, and that the restorations were only tested under static loading. One limitation of the present study was the use of a single adhesive and luting cement system, which may not fully capture the range of potential outcomes. The results could vary with the use of different systems. Additionally, important variables such as cement film thickness, bond strength, and preparation design were not evaluated. It is also worth noting that relying on a single monotonic load to induce failure might not accurately simulate real clinical conditions. Therefore, further research is necessary to explore the impact of these factors on the mechanical performance of ceramic endocrown restorations.

CONCLUSIONS

Considering the limitations of this in vitro study, the following conclusions were made:

1. The study found no significant difference in fracture resistance among endocrowns fabricated from lithium disilicate ceramic, zirconia-reinforced lithium silicate, and zirconia-reinforced lithium disilicate.
2. The fracture resistance of all tested specimens exceeded the average molar masticatory forces. Therefore, glass ceramics endocrowns may be a suitable treatment option for endodontically treated teeth.

Clinical Recommendations

1- Based on the study's findings and the existing literature, provide practical recommendations for clinicians regarding the selection and use of endocrown restorations.

2- Consider discussing factors such as the appropriate patient selection, tooth preparation guidelines, cement selection, and post-operative care that may contribute to the long-term success of endocrown restorations.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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