EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

VOL. 71, 711:719, JANUARY, 2025

PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360

FIXED PROSTHODONTICS AND DENTAL MATERIALS

Submit Date : 28-11-2024 • Accept Date : 25-12-2024 • Available online: 10-01-2025 • DOI : 10.21608/edj.2024.339124.3273

MARGINAL ACCURACY AND INTERNAL FIT OF ENDOCROWN CONSTRUCTED FROM LITHIUM DISILICATE CERAMICS VERSUS POLY ETHER ETHER KETONE (PEEK) (AN IN VITRO STUDY)

Mohamed Sayed Ahmed Elsaid*, Omnia Nabil** *and* Gihan El Naggar***

ABSTRACT

Statement of the problem: The use of peek for construction of endocrown has gained popularity due to its many advantages, yet limited data is available with regard to its marginal accuracy and internal fit.

Purpose: The purpose of the present study is to determine the marginal accuracy and internal fit of endocrown constructed from lithium disilicate ceramics and poly ether ether ketone (PEEK).

Methodology: 16 human lower molars were endodontically treated and prepared to receive endocrown restorations with Butt joint preparation design. Prepared teeth were equally divided into two groups, Group L: Lithium disilicate ceramics and Group P: Poly ether ether ketone. All restorations were CAD/CAM milled using five axis milling machine (CORiTEC 250i Series - imes – icore). Vertical Marginal adaptation was measured using USB Digital microscope with a built-in camera (Leica microscope) at fixed magnification of 20X. Internal fit was measured by replica technique.

Results: Lithium Disilicate endocrowns showed superior results, where they had statistically significant lower marginal discrepancy (28.86 ±12.69 μm) than PEEK (75.24 ± 28.89 μm) (P-value =0.002, Effect size =2.349) and statistically significant lower internal discrepancy (122.2±21.7 μm) than PEEK (163.1±25.1 μm) (P-value =0.043, Effect size =2.042). Regardless of the material of construction lingual side of endocrown showed the least marginal adaption and internal fit.

Conclusions: Lithium disilicate endocrowns showed better marginal adaptation and internal fit than PEEK endocrowns. Both groups exhibited clinically acceptable marginal discrepancies and fit. Accordingly, PEEK materials could be used as an alternative to Lithium disilicate for endocrown construction.

KEYWORDS: Marginal, Accuracy, internal, fit.

* Master of oral Fixed prosthodontics Faculty of Dentistry Cairo University
** Associate Professor, Fixed Prosthodontics Department, Cairo University and Newgiza University
*** Professor of Fixed Prosthodontics, Faculty of Dentistry Cairo University

INTRODUCTION

The restoration of endodontically treated teeth (ETT) that have experienced significant tissue loss remains a contentious and extensively researched topic within the field of dentistry. Generally, ETT are more subjected to failure than vital teeth. That fact is most probably due to the decreased amount of remaining sound tooth structure caused by caries, trauma, extensive cavity preparation and endodontic procedures and due to the decreased moisture content present within dentinal tubules imparting for the brittleness of the tooth [14].

It is becoming evident more and more that the quality of the coronal restoration is more critical than the quality of the endodontic filling itself in determining long-term outcomes [18]

The enduring success of endocrowns is influenced by various factors, including appropriate case selection, accurate preparation, and the selection of suitable ceramic and bonding materials. Furthermore, endocrowns offer notable advantages, such as enhanced aesthetics and mechanical properties, reduced costs, and shorter fabrication times compared to conventional methods.

Lithium disilicate ceramics are extensively utilized due to their advantageous characteristics, including excellent aesthetics, strength, and adhesion to dental structures. These ceramics can be fabricated through one of two approaches: automated technology utilizing the CAD/CAM system or the heat pressing method. Lithium disilicate CAD blocks are provided in a partially crystallized state, and the subsequent crystallization process facilitates a regulated increase in grain size (ranging from 0.5 to 5 μm), resulting in the final configuration of this glass ceramic. [19]

High-strength resins have emerged as a viable substitute for ceramic materials, encompassing polyaryletherketone (PAEK), polyetheretherketone (PEEK), and polyetherketoneketone (PEKK) materials.

A modified PEEK material that incorporates 20% ceramic fillers (BioHPP; Bredent GmbH) is suitable for the production of prostheses through either the lost wax press technique or CAD-CAM methods. The benefits of utilizing this material include the prevention of allergic reactions, excellent wear resistance, favorable polishing characteristics, and minimal plaque affinity.

Marginal adaptation and internal fit are regarded as critical criteria in the clinical evaluation and effectiveness of fixed restorations. Indeed, marginal misalignment can lead to significant consequences, potentially resulting in the failure of the prosthesis. Substantial marginal discrepancies can expose the luting agent to the oral environment. It is essential for the internal fit to be consistent in order to maintain both the retention and resistance of the crown, while also ensuring an adequate space for luting[23].

The null hypothesis of this study posited that there would be no significant difference in marginal accuracy and internal fit between endocrowns fabricated from lithium disilicate and those made from poly ether ether ketone (PEEK).

METHODOLOGY

1) Teeth selection:

16 Molars were selected free of cracks and caries and were stored in distilled water. Dimensions of the teeth were (7±1mm) bucco-lingual and (10 ±1.5mm) Mesio-distal measured by using a digital caliper. Scaling with ultrasonic woodpecker scaler made by Guilin Woodpecker Medical Instrument Co., Ltd. China and cleaning was carried out to remove calculus and remnants of debris.

2) Root canal treatment:

All teeth underwent conventional endodontic procedures. The access cavity was created utilizing a high-speed hand piece with abundant irrigation.

Initially, a high-speed round diamond bur was employed to establish the access cavity, followed by cavity flaring using a high-speed Carbide Endo-Z bur manufactured by Dentsply Maillefer, located in Ballaigues, Switzerland. The working length was determined to be 0.5 mm short of the apex.

3) Teeth mounting:

After endodontic treatment, teeth were placed in the epoxy resin molds. Indentations were made on the roots of the teeth using diamond stone* to facilitate the retention of tooth in resin.

4) Grouping and Randomization of samples

Grouping:

The mounted molars were divided into two equal groups according to the material of construction:

Group (L): included endocrowns constructed from Lithium disilicate ceramics (n = 8).

Group (P): included endocrowns constructed from PEEK dental blank (n = 8).

5) Endocrown preparation design:

Butt joint design was selected for the preparation of endocrown in the present study.

Cavity walls were prepared at 6–8 degree taper and occulsal clearance was set at 2mm by using diamond inverted bur. All internal line angles were smoothened. Intrachamber extension was adjusted at 3-4mm and verified by periodontal probe as shown in Figure (1). **Elalem et al (2019).**

6) Endocrown manufacturing

Scanning phase:

Extra oral scanning was carried out of the prepared molars by EDGE extraoral scanner (DOF scanner, Korea) that is capable of scanning fine details, and the scan was saved as STL file.

Designing phase:

Once the scanning was completed, the saved STL file was exported to exocad software (DentalDB 2.2 Valleta) and designing was started for endocrown. With the purpose of standardization, the restoration parameters were fixed for all the restorations with the cement gap set at 50 microns **(Elalem et al. 2019)** and 1mm from margin was free of cement as shown in Figure (2).

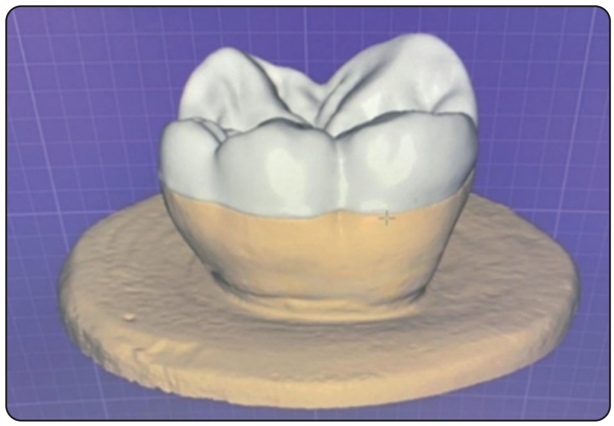

Fig. (2) Virtual design of endocrown

Milling phase:

Finally, STL file of the designed endocrown was saved and exported to a five axis milling machine (CORiTEC 250i Series - imes – icore) for production.

Eight endocrowns were produced from IPS e.max CAD blocks by wet diamond grinding manufacturing process and eight endocrowns were produced from brecam.BioHPP blank by wet carbide milling manufacturing process.

Crystallization of Lithium disilicate restoration

After milling of Lithium disilicate endocrowns, separate the endocrown from sprues of blocks then they were subjected to crystallization cycle in programat EP3010 furnace according to the manufacturer's instructions to obtain the final properties of Lithium disilicate ceramics.

7) Testing:

a) Marginal adaptation testing

Each endocrown was placed on the prepared molar and fixed in place using a specially designed holding device during marginal gap evaluation as shown in Figure (3).

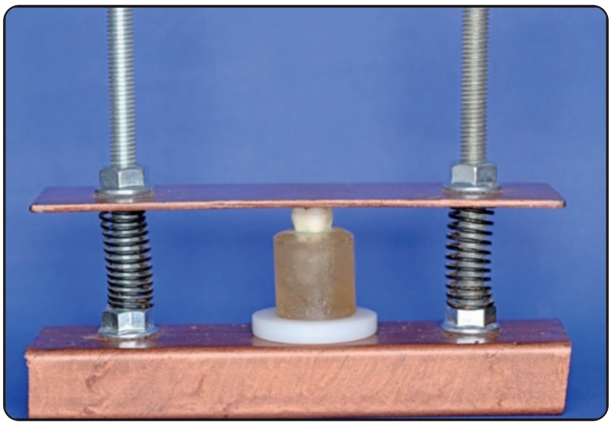

Fig. (3): Holding device

Endocrowns were photographed at different surfaces of the margins using USB stereomicroscope (Leica) as shown in Figure (4). A built-in camera was utilized, interfacing with an IBM-compatible personal computer at a fixed magnification of 20X. Subsequently, morphometric measurements were conducted for each image, involving the selection of 5 points along the circumference of each interface, resulting in a total of 20 points measured across the entire circumference of the crown.

b) Internal fit testing:

Internal fit was measured using the replica technique as recommended by **Ghoul and Salameh (2020).** Each Endocrown preparation was filled with light-body silicone. Then the endocrown was seated in its place on the prepared tooth.

All samples were individually mounted on a holding device with a load of 750 gram for 10 min until material sets. Once the light-body silicone had cured, the endocrown was detached with a sharp blade, and putty-body silicone was employed to reinforce the light-body silicone through manual

Fig. (4): Stereomicroscope

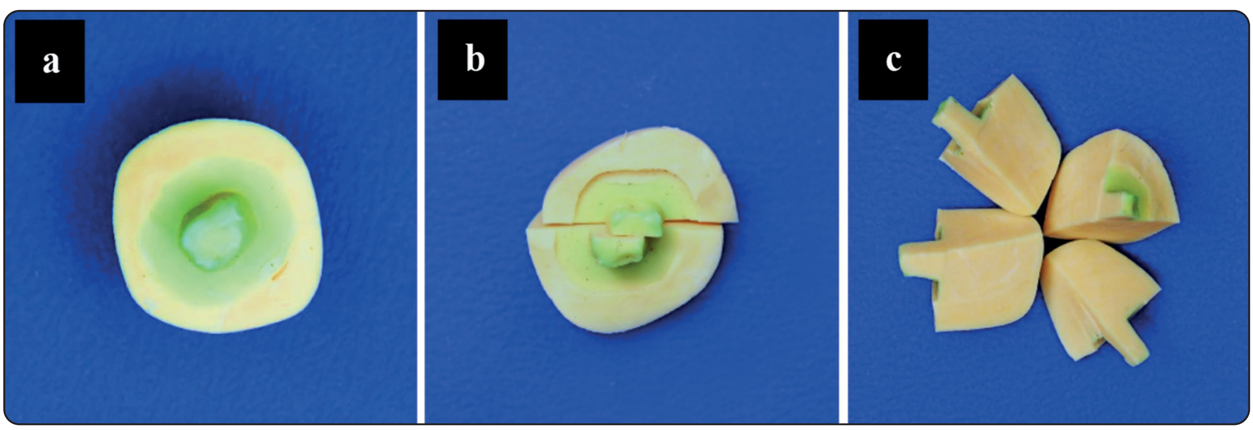

Fig. (5): Replica for internal fit (a) before sectioning (b) replica sectioned into two segments (c) replica sectioned into four segments.

pressure. Utilizing a blade (n°.15c), the replicas were meticulously divided into four equal parts. Each part was then designated and labeled as mesiobuccal (MB), distobuccal (DB), mesiolingual (ML), and distolingual (DL) as shown in Figure (5).

RESULTS

Results of the marginal accuracy testing (μm)

1. Results of the marginal accuracy testing of Lithium disilicate versus PEEK endocrowns

With regard to the overall discrepancy; Lithium Disilicate endocrowns showed statistically significantly lower marginal discrepancy (better adaptation) than PEEK endocrowns (*P*-value = 0.002, Effect size = 2.349) are presented in Table (1).

2 Results of the comparison of the marginal accuracy testing between sides of each tested endocrown.

With regard to Lithium Disilicate endocrown; there was a statistically significant difference between marginal discrepancies at different sides (P-value = 0.004, Effect size = 0.562). Pair-wise comparisons between the sides revealed that lingual side showed the statistically significantly highest discrepancy (lowest fit). Distal side showed statistically significantly lower discrepancy. There was no statistically significant difference between distal and buccal sides; both showed the statistically significantly lowest marginal discrepancies (best fit).

With regard to BioHPP endocrown; there was a statistically significant difference between marginal discrepancies at different sides (P-value <0.001, Effect size = 0.777). Pair-wise comparisons between the sides revealed that lingual side showed the statistically significantly highest discrepancy (lowest fit). Distal side showed statistically significantly lower discrepancy followed by buccal side. Mesial side showed the statistically significantly lowest marginal discrepancy (best fit).

Results of the Internal fit

1. Results of the Internal fit of Lithium disilicate versus PEEK endocrowns (μm)

With regard to the overall discrepancy; Lithium Disilicate endocrowns showed statistically significantly lower internal discrepancy (better fit) than PEEK endocrowns (*P*-value = 0.043, Effect size = 2.042).

2. Results of the comparison of the internal fit between sides of each endocrown in both tested groups.

With regard to Lithium Disilicate group and PEEK group; there was no statistically significant difference between internal fit at different sides in both tested groups (*P*-value = 0.682, Effect size = 0.125) and (*P*-value = 0.753, Effect size = 0.1), respectively.

TABLE (1) Descriptive statistics and results of Mann-Whitney U test for comparison between marginal discrepancies (μm) of the two tested materials:

Side		Lithium Disilicate	BioHPP	*P*-value	*Effect size (d)*
Buccal	Mean (SD)	16.32 (3.63)	34.97 (29.07)	0.171	0.726
Lingual		45.26 (26.15)	149.42 (79.54)	0.006*	1.868
Mesial		17.87 (15)	22.93 (19.74)	0.629	0.238
Distal		36.01 (27.18)	93.62 (48.89)	0.012*	1.623
Overall		28.86 (12.69)	75.24 (28.89)	0.002*	2.349

DISCUSSION

One of the conservative methods that has emerged alongside advancements in adhesive and bonding technologies is the endocrown restoration. This type of restoration is designed as a monoblock solution for the rehabilitation of endodontically treated teeth. It adheres to the principle of minimally invasive preparation, achieving retention and stability by anchoring to the internal structure of the pulp chamber and the margins of the cavity. [6].

The material selected for the fabrication of endocrown restoration should properly adapt and bond to the underlying tooth structure and sustain the normal forces of mastication. Lithium disilicate material succeeded throughout the past years in providing endocrowns with high adhesive, mechanical and esthetic properties [21]. The use of PEEK as an endocrown is evolving due to its many advantages, however, limited data is available regarding its marginal and internal fit.

The purpose of this study was to compare the marginal adaptation and internal fit of endocrowns constructed from Lithium disilicate ceramic and PEEK.

In this study, in-vitro type was selected which is considered a crucial step to evaluate new materials and their behaviour and different techniques without any confounders and uncontrolled variables [7].

In the current investigation, natural teeth were utilized due to their superior representation of clinical conditions regarding morphology, architecture, size, and bonding characteristics that facilitate adhesive restorations. Molars were chosen that were devoid of cracks and caries, and they were preserved in distilled water [9].

Molar teeth of comparable average dimensions were utilized. This choice was necessitated by the extremely limited availability of suitable natural molar teeth that met the specified criteria without any defects. Consequently, it was essential to eliminate numerous teeth to achieve standardization in the selection process.

The selection of the butt joint preparation design is advantageous as it maintains the peripheral enamel layer surrounding all margins, effectively reducing microleakage at the interface between the restoration and the tooth, thereby mitigating shear stresses. Additionally, this design facilitates the removal of prismatic and inter-prismatic mineral crystals, which enhances the etching of enamel and improves the bonding of the tooth restoration[20,15].

In the current study, the restorations were produced by CAD/CAM 5 axis milling machine (250i imes–icore) to be capable of milling fine details. 5-axis milling machines proved their capability of producing more effective and higher trueness of surfaces [1].

Lithium disilicate ceramic material was chosen in this study as control material due to its bond ability to tooth structure, its sufficient strength, excellent esthetics and biocompatibility. It is considered one of the most used ceramic materials for single restorations. When used with CAD/CAM systems, it is provided in a soften state to expedite milling, and then crystallized in furnace to improve its mechanical properties [2], [19].

Also, BioHPP PEEK material was selected in our study owing to its promising properties as modulus of elasticity, wear resistance, biocompatibility, high polishing abilities and bonding to tooth structure. Generally, BioHPP PEEK can be manufactured by CAD/CAM or pressing techniques. CAD/CAM PEEK technique is expected to provide restorations with accurate margins as the sintering shrinkage of the pressing technique is avoided [3].

Both marginal accuracy and internal fit are critical fundamentals in the evaluation of performance and durability of fixed dental prostheses clinically. Inaccurate marginal adaptation will result in many drawbacks including cement decomposition and microleakage with subsequent caries formation, moreover, plaque accumulation increases causing periodontal inflammation and finally, this misfit creates points of stress concentration that affects the durability of the restoration [23].

Vertical Marginal gap was evaluated between outer cervical margin of each crown and outer surface of prepared finish line. [8]**.** This is a direct, non-invasive, commonly used method as described by Holmes et al., which measures the discrepancy at the margin at several sites. The procedure was carried out directly with each endocrown fixed on its corresponding tooth using a customized device to guarantee its adaptation. Also, the endocrowns were not cemented to exclude the physical effect of the cement itself and the method of cementation on the marginal adaptation [10]**.**

The internal fit was assessed using the silicon replica technique, recognized for its accuracy and reliability in both in-vivo and in-vitro studies, thereby demonstrating its validity. Additionally, this method is non-destructive, ensuring that neither the abutment tooth nor the restoration sustains any damage. [6, 22].

Most investigators recommend the conclusion stated by McLean and von Fraunhofer that the maximum gap should be 120 μm to be clinically accepted. In our study, it was found that the marginal gap mean value recorded for Lithium disilicate group was (28.86±12.69 μm) while the PEEK group mean value was (75.24±28.89 μm) (P-value = 0.002). Both group results are within the clinically accepted range [13].

The first part of null hypothesis was refused as Lithium disilicate endocrowns showed significantly better marginal adaptation as compared to BioHPP ones. In the authors' opinion this could be attributed to the effect of type of instruments used in CAD/CAM machining; Diamond grinding bur for Lithium disilicate group as compared to the carbide milling bur for BioHPP combined with the machining performance of Lithium disilicate glass ceramics and poly ether ether ketone (PEEK) materials.

The difference of bur machining processes was explained by **Song et al., (2020)**[19]. In the Diamond bur machining, the bur indents and scratches the surface via point contacts of several small irregular diamond grains randomly oriented on the bur. While in the Carbide bur machining, the material was eliminated by multiple sharp cutting blades of the bur, where the interaction between the material and the carbide bur involved edge contact and cutting. Edge contacts led to a substantial increase in friction compared to point contacts, resulting in significantly greater machining forces for the tungsten carbide bur in comparison to the diamond bur.

The internal fit must be consistent to ensure that neither the retention nor the resistance of the crown is compromised, while also allowing for adequate space for the luting cement. [23] carried out a systematic review to summarize the data from 90 selected articles on the fitting quality of CAD/CAM fixed restoration. They concluded that the internal fit range between 23-230μm. stated that the accepted internal gap of endocrowns ranges between 75-160µm.

In present study the second part of the null hypothesis was rejected. As regards the overall internal discrepancy, results were within the clinically accepted range. However, Lithium Disilicate (122.2±21.7 μm) showed statistically significantly lower mean values than PEEK (163.1±25.1 μm) (P-value = 0.043, Effect size = 2.042). This could be related to the effect of type of instruments used in CAD/CAM machining and the difference in the nature of machining of both materials

CONCLUSION

Within the limitations of the present study the following conclusion could be drawn:

1. Milled lithium disilicate endocrowns showed better marginal accuracy and internal fit than BioHPP endocrowns.
2. Milled Lithium disilicate and BioHPP endocrowns exhibited clinically acceptable marginal discrepancies and fit.

3. Regardless of the material of construction lingual side of endocrown shed the least marginal accuracy and internal fit.

With regard to the marginal accuracy and internal fit of endocrowns, BioHPP materials could be used as an alternative to lithium disilcate ceramics for endocrown construction.

RECOMMENDATION

Further studies are needed to:

1. Investigate the effect of cementation under cyclic loading and thermal cycling on marginal accuracy and internal fit of all ceramic and BioHPP endocrown.
2. Assess the clinincal performance of both tested endocrowns (Lithium disilicate VS BioHPP).

Conflict of interest: No conflict of interest.

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethics: This study protocol was approved by the ethical committee of the faculty of dentistry- Cairo university on: 24/9/2019, approval number: 19.9.8

REFERENCES

1. Al Hamad, K. Q., Al-Rashdan R. B, Al-Rashdan, B. A., & Baba N.Z. (2021). Effect of milling protocols on trueness and precision of ceramic crowns. Journal of Prosthodontics, 30(2),171–176.
2. Azar, B., Eckert, S., Kunkela, J., Ingr, T., & Mounajjed, R. (2018). The marginal fit of lithium disilicate crowns: Press vs. CAD/CAM. Brazilian Oral Research, 32.
3. Beleidy. M., & Ziada, A. (2020). Marginal accuracy and fracture resistance of posterior crowns fabricated from cad/cam peek cores veneered with HIPC or nanohybrid conventional composite. Egyptian Dental Journal, 66, 2541:2552.
4. Bhowmick et al 2007 Role of indenter material and size in veneer failure of brittle layer structures. Journal of Biomedical Materials Research Part B Appl Biomater. 82(1):253–9.
5. Burstein et al., 1994 Fundamentals of orthopaedic biomechanics. Williams & Wilkins.
6. Elalem, I. A., Ibraheem, R. M., & Hamdy, A. M. (2019). Clinical Evaluation of The Marginal Integrity, and Internal Fit of E-Max Endocrown Restorations with Different Marginal Preparation Designs. Ex-Vivo Study Scient Open Access Clinical Evaluation of The Marginal Integrity, and Internal Fit of E-Max Endocrown Restorations with Different Marginal Preparation Designs. Ex-Vivo Study. Journal of Dental and Oral Health, 5.
7. Faggion C. M. Jr. (2012). Guidelines for reporting pre-clinical in vitro studies on dental materials. Journal of Evidance Based Dental Practice, 12(4), 182-9.
8. Ghaffari T, Hamedi F, Fakhrzadeh V. (2016). Marginal adaptation of spinell in creram and feldspathic porclain laminate. Dent. Res. J. (Isfahan).13, 239-244 .
9. Ghajghouj, O., & Taşar-Faruk, S. (2019). Evaluation of fracture resistance and microleakage of endocrowns with different intracoronal depths and restorative materials luted with various resin cements. Materials, 12(16).
10. Habib, S. R. (2019). Digital microscopic evaluation of vertical marginal discrepancies of CAD/CAM fabricated zirconia cores. Biomedical Engineering / Biomedizinische Technik, 64(2), 207-214.
11. Kang, S. Y., Yu, J. M., Lee, J. S., Park, K. S., & Lee, S. Y. (2020). Evaluation of the Milling Accuracy of Zirconia-Reinforced Lithium Silicate Crowns Fabricated Using the Dental Medical Device System: A Three-Dimensional Analysis. Materials (Basel), 13(20), 4680.
12. Li, R. W. K., Chow, T. W., and Matinlinna, J. P. (2014). Ceramic dental biomaterials and CAD/CAM technology: state of the art. Journal of prosthodontic research, 58(4), 208-216.
13. McLean, J. & Von Fraunhofer, J, (1971). The estimation of cement film thickness by an in vivo technique. Brazilian Dental Journal, 11, 107-131.
14. Ree, M., & Schwartz R. (2010). The Endo - Restorative Interface: Current Concepts. Dental Clinics,54, 345–74.
15. Rocca, G. T., Krejci, I. (2013). Crown and post-free adhesive restorations for endodontically treated posterior teeth: from direct composite to endocrowns. Eur J Esthet Dent.,8(2):156–79.
16. Samran et al 2015. Effect of ferrule location on the fracture resistance of crowned mandibular premolars: An in vitro study. The Journal of prosthetic dentistry.114(1):86–91.

17. Shin, Y., Park, S., Park, J. W., Kim, K. M., Park, Y. B., & Roh, B. D. (2017). Evaluation of the marginal and internal discrepancies of CAD-CAM endocrowns with different cavity depths: An in vitro study. Journal of Prosthetic Dentistry, 117(1), 109–115.

18. Skupien, J. A., Opdam, N. J., Winnen R., Bronkhorst, E. M., Kreulen, C. M., Pereira-Cenci, T., & Huysmans, M. C. (2016). Survival of Restored Endodontically Treated Teeth in Relation to Periodontal Status. Brazilian Dental Journal, 27(1), 37-40.

19. Song, X-F., Kang, N., & Yin, L. (2020). Effect of bur selection on machining damage mechanisms of polymer-infiltrated ceramic network material for CAD/CAM dental restorations. Ceramics International, 46.

20. Taha, D., Spintzyk, S., Sabet, A., Wahsh, M., & Salah, T. (2018). Assessment of marginal adaptation and fracture resistance of endocrown restorations utilizing different machinable blocks subjected to thermomechanical aging. Journal of Esthetic and Restorative Dentistry, 30(4), 319–328.

21. Tammam, R. (2021). Clinical evaluation of monolithic Zirconia (5Y), Lithium Disilicate and modified PEEK CAD-CAM endocrown materials,3-year clinical prospective study. Egyptian Dental Journal. 67. 635-650.

22. Tamac, E., Toksavul, S., & Toman, M. (2015). Clinical marginal and internal adaptation of CAD/CAM milling, laser sintering, and cast metal ceramic crowns. Journal of Prosthetic Dentistry. 4, 68-73

23. Vojdani, M., Safari A., Pardis, S., & Mahdavi, F. (2015). The effect of porcelain firing and type of finish line on the marginal fit of zirconia copings. Journal of dentistry Shiraz university of medical science, 16, 113-120.