EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 70, 1577:1585, April, 2024

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 02-01-2024 • Accept Date : 14-01-2024 • Available online: 10-04-2024 • DOI : 10.21608/EDJ.2024.260166.2859

MARGINAL FIT AND FRACTURE RESISTANCE EVALUATION OF INLAY RETAINED FIXED PARTIAL DENTURE WITH TWO DIFFERENT CAVITY DESIGNS

Doaa Ali Ahmed*, Shereen Kotb Salem** and Raiesa Mohamed Hashem***

ABSTRACT

Aim: An assessment of fracture resistance and marginal fit of zirconia inlay-retained fixed partial denture (IRFPD) prepared with two different cavity designs (tub shape and box shape cavity preparation).

Materials and Methods: Twenty IRFPD were constructed. Samples got divided up into two groups according to cavity design (n=10), group 1 was designed as box-shape design, while group 2 was designed in tub shape. After that, both groups were split up into two sub-groups (n=5) according to the test they were subject to; Sub-group A for fracture resistance test. And sub-group B for marginal fit test. Self-adhesive resin cement (Biscem) was used to cement all samples, were then put through a universal testing machine's fracture resistance test, while Marginal fit was computed via an optical digital microscope

Results: Showed that box shape preparation design recorded statistically significant higher fracture resistance mean value (2217.1±87.9 N) than tub shape design (1976±20.1 N). While the marginal fits of the tub-shaped preparations did not significantly differ from one another. (premolar 59±4.5μm, molar 57.4±3.6 μm) and box-shaped preparation (premolar, 60.4±4.9 μm, molar 58.4±2.5 μm)

Conclusion: Fracture resistance of zirconia inlay –retained bridges is impacted by cavity preparation, design. Regarding the preparation design the box shape cavity design demonstrated greater fracture resistance than tub shape cavity design. Every fracture resistance and marginal gap measurement was within the range that is considered clinically acceptable.

KEYWORDS: Inlay-retained, fracture resistance, marginal fit, cavity design, zirconia

* Fixed Prosthodontics, Faculty of Dentistry, Minia University, Egypt
** Associate Professor, Fixed Prosthodontics, Faculty of Dentistry, October 6 University, Giza, Egypt
*** Associate Professor, Fixed Prosthodontics, Faculty of Dentistry, Minia University, Egy

INTRODUCTION

In order to replace an extracted tooth in the posterior part of the mouth, there are various treatment options. IRFPD, the inlay retained fixed dental prosthesis, is one of the least aggressive methods.(1) There is higher tooth loss up to the two-thirds while preparing the full tooth coverage restorations, with concomitant issues including discomfort and postoperative sensitivity, than during IRFPD tooth preparation.(2).

One type of tooth-colored restorative material is monolithic zirconia-ceramic. Because of its excellent aesthetics, wear resistance, accurate contact contour, and biocompatibility with the surrounding periodontium, it has grown to be a crucial component of modern dentistry. Zirconia restoration has grown in popularity as a result of the recent technologies of computer-aided design and computer-aided manufacturing (CAD/CAM) and monolithic zirconia materials.(3) Many designs, including grooves, tubs, box-shaped proximal preparations, occluso-proximal preparations inlay designs, usage of a rest seat on the occlusal surface, lingual tooth preparation and slot preparations, were proposed by researchers for inlay retained FPDs.(4, 5)

The dimension of these preparations is determined by the tooth's size, and proximo-occlusal inlay preparation is advised for molars. [6]. A fixed dental prosthesis's durability suffers from marginal discrepancies. Although a few researchers believe marginal gaps below 100µm to be clinically acceptable, the majority of authors believe that gaps below 120µm are. [7]

The elastic modulus of the supporting form, the bonding agent's features, the restoration's thickness, and the preparatory method all affect a dental prosthesis's ability to withstand fractures. (6) Fixed dental prostheses have a varied shape due to its intricate construction, which is made up of numerous concave and convex curves. Specifically, the connectors undergo higher degrees of stress than other parts of a three-unit fixed partial denture because they must be small for biological and aesthetic reasons. (7) This in vitro study's objective is to assess the fracture resistance and marginal fit of Zirconia inlay retained fixed partial denture with two different cavity designs. (Tub and box shape cavity designs)

The Hypothesis: There won't be any difference between fracture resistance and marginal fit of two cavity designs within inlay retained FPD. (Tub and box shape cavity designs)

MATERIALS AND METHODS:

Four extracted human teeth were used in these study two mandibular second premolars and two mandibular second free from carious lesions or restorations. Using an ultrasonic scaler (NSK, Nakanishi, Inc. Japan), nylon bristle brushes, and a low-speed hand piece (NSK, Nakanishi, Inc. Japan) with 30,000 rpm, the teeth were cleared of debris and any soft tissues. After that, the teeth were stored in distilled water to avoid any microbiological growth.

The collection of extracted teeth was from the Oral and Maxillo-Facial Clinic of the Faculty of Dentistry at Minia University for purposes such as diabetes, loose teeth, and periodontally affected and impacted teeth. Patients signed consent of approval to use their teeth in scientific research. The proposal was submitted by research ethics committees of the Faculty of Dentistry at Minia University. After finishing this research, the researcher got rid of the used teeth in a safe way according to Occupational Safety and Health Administration (OSHA).

There were two various cavity preparation designs used on the teeth (box and tub shapes) according to the following guidelines. A-Box shape cavity design: The proximal box's depth measured 2 mm from the cavity's base to the occlusal surface. For molar teeth, the cavity base's mesio-distal width was 6 mm, while for premolar teeth, it measured 4 mm. For the molar tooth, the buccal-lingual width of the occlusal tooth was prepared to be 3 mm, and for the premolar tooth, it was 2 mm. In both molar and premolar teeth, the occluso-cervical height of the cavity wall (the step) measured 2 mm. Mesio-distal width of premolar and molar teeth was 1 mm.[8] B- Tub shape cavity design: The proximal tub was measured 2 mm deep from the occlusal surface to the cavity base. For molar teeth, the cavity base's mesio-distal widening was 6 mm, while for premolar teeth, it measured 4 mm. For molar teeth, the bucco-lingual widening of the occlusal isthmus measured 3 mm, while for premolar teeth, it measured 2 mm. [8] **(Figure 1)**

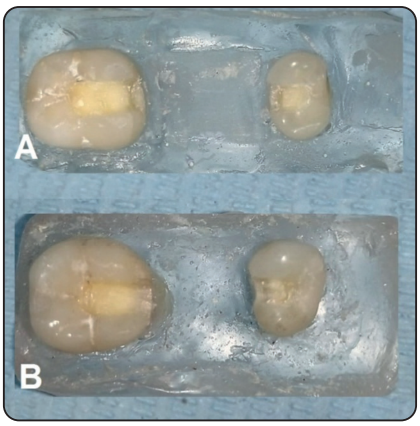

Fig. (1) A- Box shape cavity preparation B- Tub shape cavity preparation

The prepared teeth were used for preparation of twenty models; each consisting of a premolar and a molar lodged in an epoxy resin (CMB, Egypt) block, with the missing mandibular first molar represented by a 10 mm intra-abutment space. A metal mold was fabricated with fixed dimension of 40x 20x20 mm. For each sample, a mandibular first molar with a mesio-distal width of 10 mm was used to maintain a constant intra-abutment space; dental modeling wax (El-Kods Waxes Co. Egypt) was soften and placed in the metal mold. The teeth were placed parallel and at the same occlusal level in the soft wax in the metal mold with the assistance of a dental surveyor (Snow Dent in Guangdong, China).

After that, an edentulous contour was created by removing the mandibular first molar and filling the space with remodeling wax (El-Kods Waxes Co. Egypt). The putty consistency of the condensation silicone-based impression material (Zeta plus, Zhermac, Italy) was used for establishing an occlusal index. After that, the margins of the index were wrapped with a piece of remodeling wax and the mandibular second premolar and second molar were taken out of the metal cast and inserted into their appropriate locations. The manufacturer's instructions were followed when mixing and pouring epoxy resin (Kemapoxy150, CMB, Egypt) into the index using a vibrator (Omec, Maggio-MI- -Italy) after the box was sealed. After that, the boxing wax and the rubber base index were taken off of the epoxy resin model once the epoxy resin had cured. To produce 20 models, the process was repeated.

All IRFPD were fabricated with whole anatomical design according to the direction of manufacturing company (Katana Zirconia). Abutments were sprayed with 3D laser scanning spray (Shera Scanspray, Shera, Germany) of titanium dioxide to generate an identical duplicate object scans with almost no interference from reflectivity. Next, the IRFPDs were programmed on the computer software utilizing a standardized protocol. (Dental wings software, Montreal, Canada), the preparation outline was marked. Once the design phase was completed, the milling unit (Shera Eco Mil 40, Shera, Germany) was prepared by selecting milling unit icon and switching it on, then adjust milling Position icon was selected. Katana zirconia discs (98.5 mm x 14 mm) were placed in position in the milling unit. After that, samples were sintered in a special furnace (Zubler VARIO S400, Germany) based on the manufacturer's recommendations. It had taken around seven hours to finish the cycles.

On the abutment teeth, all restorations were examined before to cementation in order to ensure accurate seating. Using a customized holder for standardizing the distance, the zirconia inlay retainers' internal surfaces were sandblasted for

15 seconds at a distance of 10 mm with Al_2O_3 particles (50µm, 2.8bars, 1cm). Using Biscem self-adhesive resin cement (BISCO, INC. Schaumburg, IL USA), the cementation carried out. Applying the resin cement was done based on the manufacturer's guidelines. into the IRFPDs' fitting surface, which was then gradually seated on the abutment teeth with sufficient finger pressure to allow excess cement seepage out. A dental explorer was used to remove any excess cement after the cement was light-cured for two seconds in each direction (Dentsply, USA).To make sure the resin had fully polymerized, the IRFPD was kept in place for 5 minutes after 40 seconds of light curing on each side. The samples got ready for testing after all IRFPD had been completely cemented

Marginal fit measurements

With an established magnification of 30X, each sample was captured on using a USB digital microscope supplied with camera (U500X Digital Microscope, Guangdong, China) linked to a personal computer that is IBM in sync. It was determined how wide the gap was and assessed using a digital image analysis system (Image J 1.43U, National Institute of Health, USA). For every specimen, photos of the margins were taken. Following that, morphometric measurements were made at five equally positioned landmarks around the outline of each surface for every photograph (Occlusal, Mid-occlusal, Axio-occlusal, mid –axial, gingival). Three repeats of each measurement were conducted. **(Figure 2**)

Fracture resistance measurements:

A computer-controlled testing machine (Model 3345, Instron Industrial Products, Norwood, MA, USA) a 5 kN load was applied to test each sample individually, and data were captured using computer software (Instron® Bluehill Lite Software). Screws were tightened to firmly attach samples to the testing machine's lower fixated compartment. In order to produce a homogenous distribution of forces and minimize the transfer of individual force values, the fracture test was conducted using a metallic rod with a spherical tip (5 mm diameter) that was connected to the upper adjustable part of the testing machine and moved at a cross-head speed of 1 mm/min. An audible fracture revealed the load that was at failure that was further supported by a steep decline in the load-deflection curve. **(Figure 2**)

Statistical Analysis:

The statistical package software applied was IBM SPSS version 25. The Shapiro-Wilk test was utilized to verify the data's consistency. For parametric quantitative data, the minimum and maximum values were stated, along with the mean ± SD. Using the Independent Samples T test, analyses were performed for both of the groups of parametric quantitative data. Statistics were classified as significant if the P-value was less than 0.05.

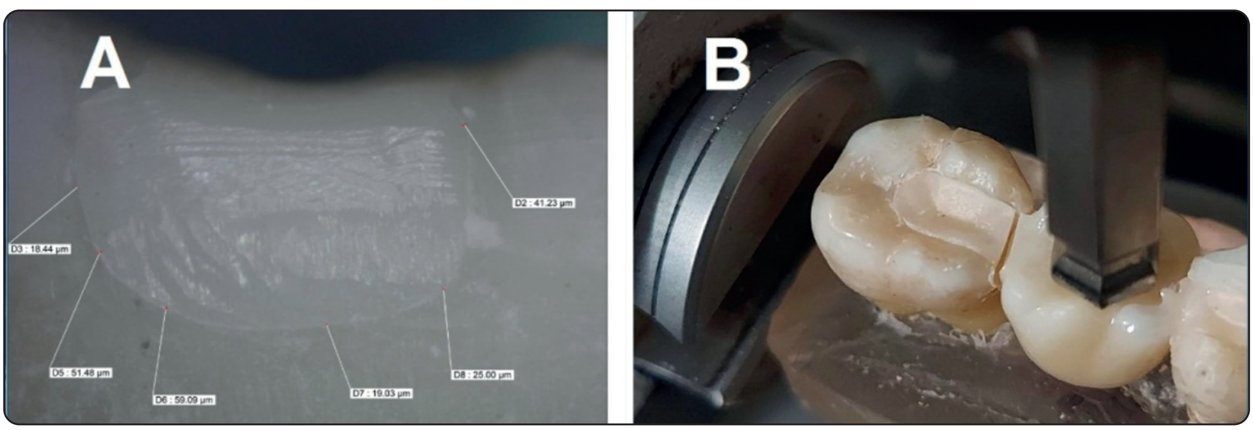

Fig. .2 (A) - Marginal fit measurements (B) - Fracture resistance measurements

RESULTS

Marginal fit (µm)

Comparison of total marginal fit results between the two designs in premolar and molar teeth.

The results showed that the better fitness value in the tub shape design (59±4.5) when compared to the box shape design (60.4±4.9) in premolar tooth and the better fitness value in the tub shape design (59±4.5) when compared to the box shape design (60.4±4.9). Statistically, there wasn't a significant difference marginal fit between both designs in premolar and molar teeth

Fracture resistance (N)

Comparison of Fracture resistance test results between the two designs.

Results showed significant difference between the two designs. These revealed that the higher mean value was recorded for the box shape design (2217.1±87.9) compared to the tub shape design (1976±20.1)

TABLE (1) Range, Mean and SD of total marginal fit between the two designs in premolar and molar teeth

	Marginal fit	Box shape Design 1 N=5	Tub shape Design 2 N=5	P value
Premolar	*Range*	(54.6-64.7)	(54.3-63.5)	*0.652*
	Mean ± SD	60.4±4.9	59±4.5	
Molar	*Range*	(55.9-61.1)	(53.7-61.3)	*0.652*
	Mean ± SD	58.4±2.5	57.4±3.6	

Independent Samples T test for quantative data between both groups

Significant difference at P value < 0.05

TABLE (2) Range, Mean and SD of fracture resistance data between two designs

Fracture resistance	Box shape Design 1 N=5	Tub shape Design 2 N=5	P value
Range	(2108-2350.2)	(1951.4-2003.5)	*<0.001**
Mean ± SD	2217.1±87.9	1976±20.1	

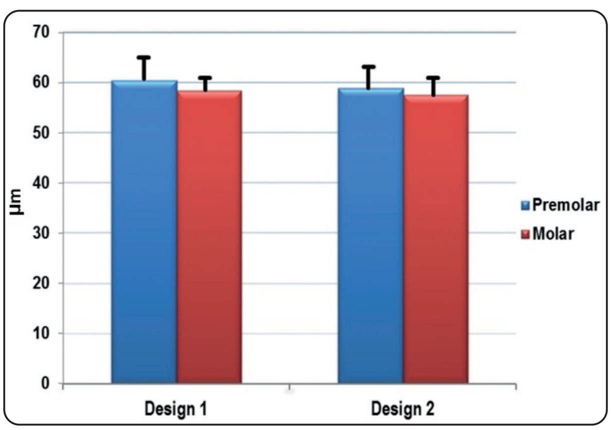

Fig. (3): Bar diagram shows total marginal fit between the two designs in premolar and molar teeth

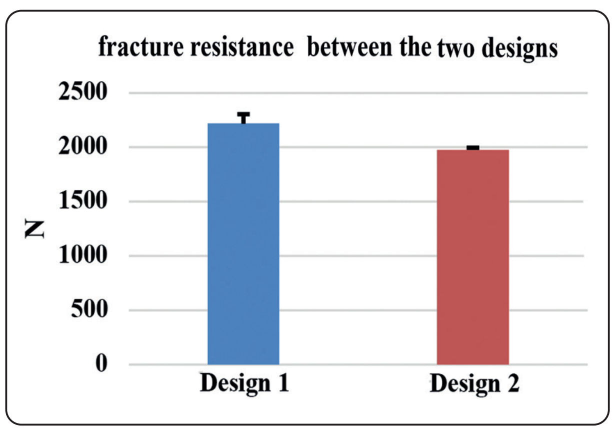

Fig. (4): Bar diagram shows the fracture resistance data between two designs

DISCUSSION

When it comes to replace a lost posterior tooth with adjacent sound teeth, an implant-supported repair is typically the best option. [9] Clinical contraindications, on the other hand, may be countered by conditions such as autoimmune diseases, hematologic disorders, uncontrolled diabetes, or multiple cancer treatments as well as other surrogate circumstances like financial difficulties or surgical anxiety[6]. For a three-unit fixed dental prosthesis, crowning adjacent teeth is usually the initial plan to follow in these situations.Nevertheless, between 63 and 73% tooth removal is needed in order to prepare teeth for a complete covering.

The usage of IRFPD has been given more thought in recent decades.[7, 10] A least-invasive strategy for posterior single tooth extraction replacement, this method preserves the integrity of the periodontal tissues and the dental structure by utilizing existing fillings consisting of gold, composite, ceramic, or any other substance applied to the neighboring teeth as retainers for box-shaped cavities.[11-13]

For the purpose of standardization, a ceramic zirconia block was utilized for each form of restorations.

The selection of a zirconia ceramic was based on its yttria-tetragonal zirconia polycrystal's higher strength and resistant to fracture [14, 15] , superior mechanical performance, and capacity to stop cracks from propagating when compared to other ceramics [16, 17]. Zirconia based ceramic IRFPDs showed greater fracture resistance than glass ceramic [18, 19].

Before being suggested for clinical usage, dental materials with novel preparation patterns must undergo testing. [19, 20] What level of fracture resistance is necessary to get Long-lasting success from IRFPDs in the molar region is unknown. Maximum biting forces during mastication were studied by numerous authors, and the mean values for this level ranged (216 N–847 N).[21, 22] The area of the first molar had the most biting force.[22]

According to studies assessing the resistance to fractures of IRFPDs, The restorations must be able to sustain mastication powers in the molar area, with a 500 N lowest load requirement. [23-25].

Teeth selection and preparation were done to replicate the clinical condition. For control and stabilization, for each sample, a mandibular first molar with a mesio-distal width of 10 mm was used to maintain a constant intra-abutment space.

Partial coverage restoration preparation techniques are not consistent, as opposed to full coverage restorations. Researchers recommended a variety of preparations, including lingual tooth reduction, retentive-slot preparations, tub, box-shaped proximal preparations, grooves, and occluso-proximal preparations, in addition to using a rest seat on the occlusal surface.[5), (14, 26),]

In this study, both designs of the IRFPD were evaluated. The box shaped and the tub-shaped preparation designs. The most popular design for IRFPD preparation is a box form. [4, 16, 27] The same operator made all the required preparations for standardization in accordance with the instructions. [8]

Teeth selection and preparation were done to replicate the clinical condition. For control and stabilization, extracted caries- free human teeth of a similar size were collected and used. On a metal mold with set dimensions (4x2x2), the teeth were positioned parallel and a mandibular first molar with a mesio-distal width of 10 mm was chosen in order to maintain constant intra-abutment spacing between the samples. Index for each bridge was constructed to provide a uniform thickness of (IRFPD).

The last phase of cementation of IRFPD was completed using Biscem TM, self-adhesive dual-cure resin cement. Using MDP-containing calcium-fluoride-releasing self-adhesive resin cement (Biscem) strengthens the bond to every surface that was tested (enamel, dentin, and zirconia), according to a research report by Mahrous et al.[28]

An optical digital microscope was utilized for calculating the marginal gap.; this is the preferred method to test how properly restorations fit and is thought to be the highest practical, accurate, simple, and fast way of measuring the marginal gap distance.[29]

Samples were laden up to fractured using a computer-controlled universal testing machine. The force (measured in Newtons) that the samples failed is revealed by the fracture resistance test. An extensive range of force values was a result of various testing techniques and the challenge of measuring masticatory forces.

Non-significant differences were found between the two preparation designs (box shape and tub shape cavity designs) in the study's results as regard marginal gap. The mean marginal gap value recorded for box shape design (60.4±4.9 μm) for premolar teeth and (60.4±4.9 μm) for molar teeth, while the mean marginal gap value recorded for tub shape design (59±4.5 μm) for premolar teeth and (57.4±3.6 μm) for molar teeth.

The current study yielded marginal gap data ranging from 46 to 71 μm, which falls within the limits of levels that are clinically sufficient. For the majority of the authors, marginal gaps less than 120μm are clinically acceptable.[30-34]

The findings indicated that the difference is statistically significant between fracture strength of tested samples regarding the two designs used in the study. Comparing the box design to the tub design, the box design has greater fracture resistance. The results were, for box shape design the fracture resistance was (2217.1±87.9 N), for tub shape design the fracture resistance was (1976±20.1 N)This could be explained by the reality that the box design, which had a 2 mm more height in its proximal box in comparison to the tub design, may have offered a larger surface area to withstand the forces[35]. This was in line with the findings of Mohsen et al [36] assessed the fracture resistance of three various zirconia IRFDP designs: tub-shaped, proximal box shaped and inlay-shaped retainers. The greatest fracture resistance measurements were found in IRFDPs with inlay-shaped retainers, followed by those with tub-shaped retainers and, lastly, those with proximal box-shaped retainers, which had the most low fracture resistance measurements.

The hypothesis of this study was partially rejected, since statistically significant differences were found in fracture resistance according to the cavity preparation designs of the inlay retained fixed partial dentures.

This study may have some limitations because loading in the clinical environment differs from loading in vitro, where the forces of mastication may operate in different directions and result in torque. The fracture resistance and marginal integration revealed that it is necessary to perform a clinical trial..

CONCLUSIONS

Fracture resistance of zirconia IRFDP is impacted by cavity preparation design. Regarding the preparation design the box shape cavity design showed a greater resistance against fracture in comparison to tub shape cavity design .All marginal gap and fracture resistance value ranged within what was considered clinically accepted.

REFERENCES

1. Augusti D, Augusti G, Borgonovo A, Amato M, Re D. Inlay-retained fixed dental prosthesis: a clinical option using monolithic zirconia. Case Reports in Dentistry. 2014;2014.

2. Castillo-Oyagüe R, Sancho-Esper R, Lynch CD, Suárez-García M-J. All-ceramic inlay-retained fixed dental prostheses for replacing posterior missing teeth: A systematic review. Journal of prosthodontic research. 2018;62(1):10-23.

3. NISTOR L, GRĂDINARU M, RÎCĂ R, MĂRĂȘESCU P, STAN M, MANOLEA H, et al. Zirconia use in dentistry-manufacturing and properties. Current health sciences journal. 2019;45(1):28.

4. Behr M, Rosentritt M, Leibrock A, Schneider-Feyrer S, Handel G. In-vitro study of fracture strength and marginal adaption of fibre-reinforced adhesive fixed partial inlay dentures. Journal of dentistry. 1999;27(2):163-8.
5. Edelhoff D, Spiekermann H, Yildirim M. Metal-free inlay-retained fixed partial dentures. Quintessence International. 2001;32(4).
6. Keulemans F, Lassila LV, Garoushi S, Vallittu PK, Kleverlaan CJ, Feilzer AJ. The influence of framework design on the load-bearing capacity of laboratory-made inlay-retained fibre-reinforced composite fixed dental prostheses. Journal of Biomechanics. 2009;42(7):844-9.
7. Karaarslan ES, Ertas E, Ozsevik S, Usumez A. Conservative approach for restoring posterior missing tooth with fiber reinforcement materials: four clinical reports. European journal of dentistry. 2011;5(04):465-71.
8. Gumus HS, Polat NT, Yildirim G. Evaluation of fracture resistance of inlay-retained fixed partial dentures fabricated with different monolithic zirconia materials. The Journal of prosthetic dentistry. 2018;119(6):959-64.
9. Bindl A, Lüthy H, Mörmann WH. Fracture load of CAD/CAM-generated slot-inlay FPDs. International Journal of Prosthodontics. 2003;16(6).
10. Göehring TN, Peters OA, Lutz F. Marginal adaptation of inlay-retained adhesive fixed partial dentures after mechanical and thermal stress: an in vitro study. The Journal of prosthetic dentistry. 2001;86(1):81-92.
11. The Academy of P. The glossary of prosthodontic terms. J Prosthet Dent. 2005;94:10-92.
12. Monaco C, Cardelli P, Bolognesi M, Scotti R, Ozcan M. Inlay-retained zirconia fixed dental prosthesis: clinical and laboratory procedures. Eur J Esthet Dent. 2012;7(1):48-60.
13. Ohlmann B, Gabbert O, Schmitter M, Gilde H, Rammelsberg P. Fracture resistance of the veneering on inlay-retained zirconia ceramic fixed partial dentures. Acta Odontologica Scandinavica. 2005;63(6):335-42.
14. Chow TW, Chung RW, Chu FC, Newsome PR. Tooth preparations designed for posterior resin-bonded fixed partial dentures: a clinical report. The Journal of prosthetic dentistry. 2002;88(6):561-4.
15. El-Mowafy OM. Posterior resin-bonded fixed partial denture with a modified retentive design: a clinical report. Journal of Prosthetic Dentistry. 1998;80(1):9-11.
16. Ohlmann B, Rammelsberg P, Schmitter M, Schwarz S, Gabbert O. All-ceramic inlay-retained fixed partial dentures: preliminary results from a clinical study. Journal of Dentistry. 2008;36(9):692-6.
17. Kern M, Strub J. Bonding to alumina ceramic in restorative dentistry: clinical results over up to 5 years. Journal of dentistry. 1998;26(3):245-9.
18. Magne P, Perakis N, Belser UC, Krejci I. Stress distribution of inlay-anchored adhesive fixed partial dentures: a finite element analysis of the influence of restorative materials and abutment preparation design. The journal of prosthetic dentistry. 2002;87(5):516-28.
19. Wolfart S, Ludwig K, Uphaus A, Kern M. Fracture strength of all-ceramic posterior inlay-retained fixed partial dentures. Dental Materials. 2007;23(12):1513-20.
20. McLean JW. Evolution of dental ceramics in the twentieth century. Journal of Prosthetic Dentistry. 2001;85(1):61-6.
21. Gibbs CH, Mahan PE, Lundeen HC, Brehnan K, Walsh EK, Sinkewiz SL, et al. Occlusal forces during chewing-influences of biting strength and food consistency. J Prosthet Dent. 1981;46(5):561-7.
22. Waltimo A, Könönen M. A novel bite force recorder and maximal isometric bite force values for healthy young adults. European Journal of Oral Sciences. 1993;101(3):171-5.
23. Chen J, Cai H, Suo L, Xue Y, Wang J, Wan Q. A systematic review of the survival and complication rates of inlay-retained fixed dental prostheses. Journal of dentistry. 2017;59:2-10.
24. Iglesia-Puig MA, Arellano-Cabornero A. Inlay fixed partial denture as a conservative approach for restoring posterior missing teeth: a clinical report. The Journal of prosthetic dentistry. 2003;89(5):443-5.
25. STEVENSON III RG, Refela JA. Conservative and esthetic cast gold fixed partial dentures—inlay, onlay, and partial veneer retainers, custom composite pontics, and stress breakers: part II: utilization of additional retentive features and fabrication of custom pontic facings. Journal of Esthetic and Restorative Dentistry. 2009;21(6):375-84.
26. El-Mowafy O, Rubo MH. Retention of a posterior resin-bonded fixed partial denture with a modified design: an in vitro study. International Journal of Prosthodontics. 2000;13(5).

27. Kılıçarslan MA, Kedici PS, Küçükeşmen HC, Uludağ BC. In vitro fracture resistance of posterior metal-ceramic and all-ceramic inlay-retained resin-bonded fixed partial dentures. The Journal of prosthetic dentistry. 2004;92(4): 365-70.

28. Mahrous A, Radwan MM, Kamel SM. Micro-shear bond strength of novel MDP calcium-fluoride-releasing self-adhesive resin cement after thermocycling. Int J Periodontics Restor Dent. 2020;40:445-55.

29. El-Khodary N, El-Meged Katamesh H, Halim C. In vitro fracture resistance and marginal accuracy of zirconia inlay-retained fixed partial denture: A systematic review. Indian J Sci Technol. 2016;9:1-7.

30. Komine F, Blatz MB, Matsumura H. Current status of zirconia-based fixed restorations. Journal of oral science. 2010;52(4):531-9.

31. Borba M, Cesar PF, Griggs JA, Della Bona Á. Adaptation of all-ceramic fixed partial dentures. Dental Materials. 2011;27(11):1119-26.

32. Beuer F, Naumann M, Gernet W, Sorensen JA. Precision of fit: zirconia three-unit fixed dental prostheses. Clinical oral investigations. 2009;13:343-9.

33. Subasi G, Ozturk N, Ozgur I, Bozogullari N. Evaluation of marginal fit of two allceramic copings with two finish lines. European journal of dentistry. 2012;6(02):163-8.

34. Bindl A, Mörmann W. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. Journal of oral rehabilitation. 2005; 32(6):441-7.

35. Song H-Y, Yi Y-J, Cho L-R, Park D-Y. Effects of two preparation designs and pontic distance on bending and fracture strength of fiber-reinforced composite inlay fixed partial dentures. The Journal of prosthetic dentistry. 2003; 90(4):347-53.

36. Mohsen CA. Fracture Resistance of Three Ceramic Inlay-Retained Fixed Partial Denture Designs. An In Vitro Comparative Study. Journal of Prosthodontics: Implant, Esthetic and Reconstructive Dentistry. 2010;19(7):531-5.