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Influence of Two Preparation Designs on Fracture Strength of Premolar Endocrown Restoration

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ABSTRACT:Objective: An in-vitro study, to evaluate the effect of different two preparation designs on the fracture resistance of maxillary premolars endcrowns made of high translucent zirconia.

Materials and Methods: Ten endodontically treated upper first premolars were randomly divided into two groups (n = 5) according to occlusal preparation designs (conventional butt joint and Anatomical). After teeth preparation, the restorations were all made by CAD/CAM system. After proper surface treatment for all endo-crowns, the restorations were cemented using self-adhesive resin cement (G CEM ONE ^{TM}). All specimens were thermo-cycled for 2500 cycles in a water bath between 5º C and 55º C. all samples were loaded to fracture using a universal testing machine for recording the fracture resistance values in N . The specimens were measured and statistically analyzed. Mann Whitney U test was used to compare between 2 studied groups for non-normally distributed data.

Result:There was a significant difference in fracture resistance between two different designs ($P \leq 0.05$). The highest mean fracture load value was recorded for the anatomical group, while the lowest value was recorded for the conventional group.

Conclusions: Anatomical preparations were found to be more favourable in restoring endodontically treated maxillary premolars.

KEYWORDS: Endodontically treated teeth, CAD/CAM, Endo-crowns, Maxillary premolars and fracture resistance.

I. INTRODUCTION

The endodontically treated teeth (ETT) have structural and physical changes that in turn influence properties of dentine such as modulus of elasticity, microhardness, and fracture toughness, so treatment of non-vital dehydrated teeth should aim to protect and strengthen the remaining tooth structure.[1, 2] Endo-crown is a conservative treatment modality to restore ETT that uses the pulp chamber as a source of retention. [3] In 1995, Pissis was the pioneer of a technique that used porcelain post and crown as one unit, called the mono-block porcelain technique, to replace conventional metal post and core. [4] But the term "endo-crown" was released for the first time by Bindl and Mormann as an adhesive endodontic crown, and it was as a total ceramic crown fixed to a non-vital tooth. [5] It is defined as a bonded restoration that consists of a coronal portion and an apical projection fixed to the pulp chamber to obtain macro-mechanical retention, while the adhesive resin cement acts as micromechanical retention. [6] Endo-crown is indicated to restore teeth with insufficient vertical dimension or badly broken teeth to preserve the maximum amount of tooth structure and also for short clinical crowns.

In addition, they are mandatory in teeth with severely curved and obliterated roots and in teeth with inadequate ferrules. [7] The design of the preparation of the endocrown should provide sufficient stability, structural durability and retention of the restoration. Endocrowns strictly adhere to this rational preparation, which includes equai-gingival or supra-gingival circular butt joint margins while retaining as much enamel as possible to improve adhesion. Endocrowns enter the pulp chamber only, in which the shape of the pulpal chamber ensures stability and retention with no need for further preparation. The saddle form of the pulpal floor improves stability. [8]

The question that still needs to be answered is how suitable it is to restore endodontically treated premolars (ETPM) by endocrown restoration. Numerous studies stated that those teeth have a high fracture incidence, especially maxillary ones, as a combination of compressive and shearing forces are applied to them, making them more liable to fracture. [9]

A wide range of ceramic materials had been available for CAD/CAM technology. Zirconia can be used for endo-crown restoration. [10]However, it differs from glass ceramics as it is not liable to acid etching technique, so it doesn't have the advantages of the adhesive bonding procedure.[11]

The final critical step in restoring teeth with indirect restorations is cementation. The longterm performance and longevity of restorations depend on the success of bonding between restorative materials, adhesive agents, and tooth substrate. Self-adhesive resin cement was introduced and obtained popularity rapidly. They are polymerizing cement that can bond to tooth structure without needing to pretreat by etching, primer, or bonding agent, so cementation is done in one step. [12] The performance longevity of the endocrowns depends on many factors: proper case selection, proper preparation, and choice of suitable restorative materials and suitable adhesive cementation are necessary for the success of this restorative treatment. The current study aimed to evaluate fracture resistance of two different designs of Endocrown restorations luted to maxillary premolars. The Null hypothesis was that no effect of different designs on fracture resistance of an endocrown restoration.

II. MATERIALS AND METHODS

This research was approved by the committee of Faculty of Dentistry Mansoura University Research Ethics (A01010621FP). Recently extracted ten human maxillary first premolars, without caries or visible fracture lines were selected with similar buccolingual (BL) and mesiodistal (MD) dimensions, as determined with a digital caliper allowing narrow range of deviation. Teeth were selected from the Department of Oral Surgery Faculty of Dentistry Mansoura University. The reasons for teeth extraction varied from periodontal disease, mobility of teeth due to systemic diseases such as diabetes, or extraction for an orthodontic reason. Teeth were cleaned with ultrasonic scaler, then all teeth were stored in saline solution at room temperature to avoid dehydration .

All the teeth were endodontically treated using the same sequence and by the same operator for the purpose of standardization.The pulp chamber was accessed following its own pulp chamber morphology via a round carbide high speed bur. Canal lengths were determined visually by-passing size #10 K-file through the root canals until being obvious at the apical foramen, working lengths were adjusted 1 mm short from apical foramen. The root canals were prepared till rotary file size F2 (Protaper, Dentsply, Maillefer, Switzerland). Resin sealer (ADSEAL, Meta-Biomed, Korea LOT ADS2104141) was used to coat the Gutta-percha cone and placed into the root canal then lateral condensation by using a spreader. The red hot condenser was used to remove excess Guttapercha.

All teeth were centralized in the resin epoxy blocks (Kema Epoxy 150, Egypt) at 2 mm below the cemento-enamel junction (CEJ) by using a special centralization device. The selected teeth were randomly divided into two groups (n =5) according to the design of the preparation.

A dental surveyor (Surveyor, Marathon-103, Saeyang Company) was used to standardize all preparations of all specimens. The preparation criteria for each group are shown in (Figure 1). Group C represents teeth that were prepared with a butt joint preparation design. Group A represents teeth that were prepared with an anatomical occlusal preparation design. For group C the crowns were reduced horizontally by using a super coarse diamond disc till the level of 3mm coronal to CEJ. For group A teeth were prepared with anatomical occlusal preparation. The pulp chamber was prepared to the depth of 6mm from decapitated level with 8º divergence walls. At this stage, kidney-shaped access cavities were partially filled with a 2mm layer of flowable composite resin material (Nexcomp Flow A2) after application of a thin coat of a light-cured universal dental adhesive (All-Bond Universal). This adhesive was worked into the cavity for 10-15 seconds, air-thinned for 10 seconds and light-cured for 10 seconds using a LED light-curing unit (WOODPECKER i led), according to the manufacturer’s instructions.

(MEDIT) intraoral scanner was used for scanning the preparations and CAD/CAM software (Ceramill Mind, AmannGirrbach) was used to design all endo-crown restorations. For group C, the endo-crown height to the buccal cusp tip was 5 mm and to the palatal cusp tip was 4 mm to standardize forms of all restorations. And with group A, the endo-crown height to the buccal cusp tip was 3 mm and to the palatal cusp tip was 2.5 mm with cement space 50µm (Fig.1,2).High translucent zirconia disk (Nacera Pearl Shaded A3) was used for endocrown fabrication as recommended by the manufacturer. Final restorations were measured with a digital caliper for verification of the occlusal thicknesses and the endocore depth extension.

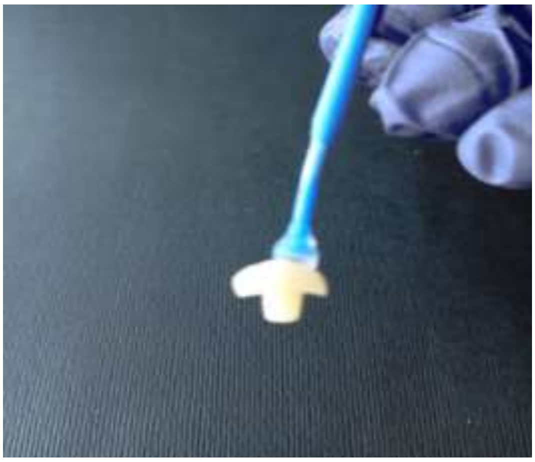

Fig.(1) show anatomical endocrown .

Fig.(2) show conventional endocrown .

Fitting surfaces of all zirconia endocrowns were sandblasted by alumina oxide particles (50µm, 2.5 bar, 10 sec, 10 mm distance). Then all restorations were cleaned and Z-PRIME (Bisco) was applied. The enamel surface of all prepared teeth was selectively etched with 37% phosphoric acid for 30 sec, washed with water-air spray for 30 sec, and dried for 5 sec with oil-free air. G-CEM ONE^{TM}(self-adhesive resin cement) was applied on prepared teeth by using the auto- mix tip and then the restoration was seated in its place by static finger pressure then the especially loading device was used. The excess cement was removed with a scaler(Fig 3), and then light curing was done for 20 s for each side. The specimens were stored in distilled water at 37 0C for 24 h.

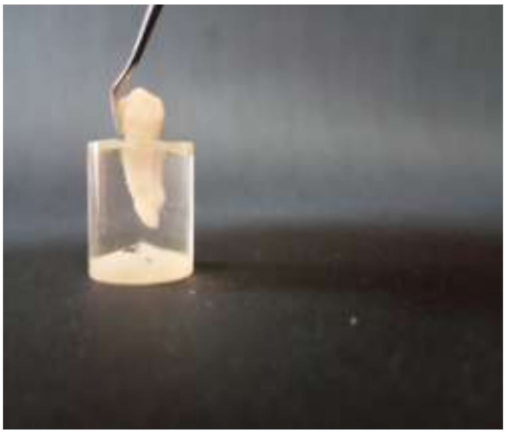

Fig (3) show excess cement removal.

All specimens were loaded vertically on the central fossa of their occlusal surfaces in a universal testing machine (5ST,Tinius Olsen, England) until fracture occurred. The load by a 4mm diameter round-end stainless steel stylus was centered along the long axis of the specimens with a crosshead speed of 0.5 mm/min. The breaking load was recorded in Newtons (N). Statistical analyses were performed with Mann Whitney U test to compare between 2 studied groups for non-normally distributed data.

III. RESULT

The highest fracture load value was recorded for the A group while the lowest value was recorded for the C group. Statistically, analysis using the Mann Whtney U test appeared a significant difference between two different tested groups at (P ≤0.05) as shown in (Table 1).(Fig3)

Table(1):comparison of fracture resistance between studied groups

	Conventional	Anatomical	Test of significance
Fracture resistance (N) **Median (min-max)**	1643.66 (848.72-3783.42)	3217.16 (2370.89-3621.72)	Z=0.117 P=0.151

Z:Mann Whitney U test

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Table (1): demonstrates no statistically significant difference between studied groups as regard fracture resistance (p=0.151) .Higher median fracture resistance is detected among anatomical than conventional group(3217.16 ranging from 848.72 to 3783.42 versus 1643.66 ranging from 848.72 to 3783.42 .

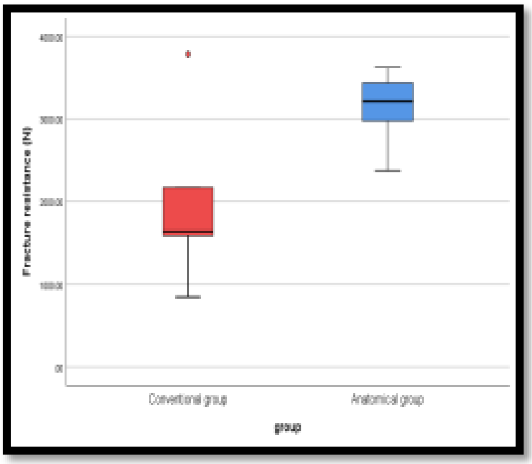

Figure (3): box and whisker plot showing fracture resistance between studied groups

Statistical analysis and data interpretation:

Data analysis was performed by SPSS software, version 25 (SPSS Inc., PASW statistics for windows version 25. Chicago: SPSS Inc.). Qualitative data were described using number and percent. Quantitative data were described using median (minimum and maximum) for non-normally distributed data after testing normality using Kolmogrov-Smirnov test . Significance of the obtained results was judged at the (≤0.05) level .Mann Whitney U test was used to compare between 2 studied groups for non-normally distributed data.

IV. . DISCUSSION

The null hypothesis of this study was rejected because the different designs had a statistically significant effect on both fracture resistance . With the recent improvements in adhesive dentistry and new ceramic materials, more conservative treatment techniques such as endocrown have been introduced to restore ETT due to a macro-retentive design if there are adequate tooth surfaces for bonding. [13] In this study, natural teeth were selected to mimic the clinical situation in terms of architecture, size, morphology, and bonding properties, all of which are favorable to adhesive restorations.Epoxy resin material was used as embedding material around the roots of teeth because its modulus of elasticity is near to that of human bone. [14] Maxillary premolars were used to evaluate the success rate of different restoration materials restoring such teeth with their unique anatomy together with special morphology that is more susceptible to fracture under occlusal loads and cusp deflection. [15] All teeth were cut at the right angle to the long axis of each tooth 2mm coronal to CEJ proximally to mimic the condition of the compromised severely damaged ETT premolars. [16]Butt joint preparation design was chosen to preserve the outer enamel layer around all margins, which is effective in decreasing micro-leakage at the restoration-tooth interface and thereby reducing shear stresses. Furthermore, the design of butt joint preparation was able to eliminate the prismatic and inter-prismatic crystals, allowing for better enamel etching and tooth restoration bonding. [14]Anatomical cusp reduction design proved to have better fracture resistance with a favourable fracture pattern due to the axial direction of the cusp reduction design, which would lead to a favorable distribution of occlusal forces and transfer to the tooth structure when a compressive load is applied [17].

G Cem ONE (self-adhesive resin cement) was used in this study as its technique of application was easier, faster, and had low sensitivity.Self-adhesive resin cement in combination with the total-etch bonding technique was selected as it is the gold standard technique to get optimum bonding. [18] To obtain excellent bond strength of Zirconia restorations, the internal surface was treated with airborne-particles abrasion (Al2O3) followed by the application of adhesive containing MDP phosphate monomer (10-methacryloyloxy decyldihydrogen phosphate). Casado et al. (2017) [19] stated that using self-adhesive resin cement in combination with adhesive containing MDP monomers gave the highest bond strength among other groups. MDP was provided direct bifunctional adhesion with Bis–GMA matrix and metal oxides, resulting in a stronger chemical bond between surfaces.to obtain micro-roughness of the PEEK surface then methyl methacrylate monomer (Visio. Link) was painted on the surface to increase wetting of the veneering material with an adequate chemical bond. Results of the fracture resistance test showed that the highest mean fracture load value was recorded for Agroup followed by C group. Results of this study were in agreement with those Elashmawy et al. (2020) [10]reportedthatthe fracture resistance of endo-crown fabricated from zirconia material is higher than those fabricated from lithium disilicate and PEEK. Ahmed et al. (2021)[20] supported the outcome of this study as they found a significant increase in fracture resistance of zirconia than lithium disilicate and attributed this to the microstructure of the restorative materials which affects the survivability and fracture strength of restorative materials and abutment tooth itself.

V. CONCLUSION

Within the limitations in this study the following conclusions could be withdrawn:
1. All tested endocrowns showed fracture resistance values within the range of the maximum chewing forces in the posterior area and survived the chewing simulator;
2. Anatomical occlusal reduction significantly improved the fracture resistance of endocrowns in upper premolars.
3.It would be safe to suggest the utilization of the high translucent zirconia for restoring theendodontically treated upper first premolars .

REFERENCES

[1]. Koseoglu M, Furuncuoglu F. Effect of Polyetheretherketone and Indirect Composite Resin Thickness On Stress Distribution in Maxillary Premolar Teeth Restored with Endocrown: A 3D Finite Element Analysis. J. Biotechnol. 2020; 4:298-305.
[2]. Kanat- Erturk B, Saridag S, Koseler E, Hel Vacioglu-Yigit D, Avcu E, Yildiran-Avcu Y. Fracture strengths of endocrown restorations fabricated with different preparation depths and CAD/CAM materials. Dent Mater J. 2018; 37:256-265.
[3]. Turkistani AA, Dimashkieh M, Rayyan M. Fracture resistance of teeth restored with endocrowns: An in vitro study. J Esthet Restor Dent. 2020; 32:389-394.
[4]. Pissis P. Fabrication of a metal-free ceramic restoration utilizing the monobloc technique. Pract Periodontics Aesthet Dent. 1995; 7:83-94.
[5]. Bindl A, Mormann WH. Clinical evaluation of adhesively placed Cerecendo-crowns after 2 years-preliminary results. J Adhes Dent. 1999; 1:255-266.
[6]. El Ghoul WA, Özcan M, Ounsi H, Tohme H, Salameh Z. Effect of different CADCAM materials on the marginal and internal adaptation of endocrown restorations: An in vitro study. J Prosthet Dent. 2020; 123:128-134.
[7]. Eisa NS, Essam EA, Amin RA, EL Sharkawy ZR. Fracture Resistance and Retention of Three Different Endocrown Materials. Al-Azhar dent. J. girls. 2020; 7:189-198.
[8]. Elagra ME. Endocrown preparation. Int J Appl Dent Sci.2019; 5:253-256.
[9]. Fráter M, Lassila L, Braunitzer G, Vallittu PK, Garoushi S. Fracture resistance and marginal gap formation of post-core restorations: influence of different fiberreinforced composites. Clin Oral Investig. 2020; 24:265-276.
[10]. Elashmawy Y, Elshahawy W, Seddik M, Aboushelib M. Influence of fatigue loading on fracture resistance of endodontically treated teeth restored with endocrowns. J Prosthodont Res. 2020; 485.
[11]. Zarone F, Di Mauro MI, Ausiello P, Ruggiero G, Sorrentino R. Current status on lithium disilicate and zirconia: a narrative review. BMC Oral Health. 2019; 19:134.
[12]. Ayesha N, Ali SM, Shastry YM, Reddy KM. A Comparative Assessment of Bond Strength of PEEK Crowns to Natural Teeth with Two Different Resin Cements. Int J Dent Med. 2020; 6:7-12.
[13]. Taha D, Spintzyk S, Schille C, Sabet A, Wahsh M, Salah T, Geis-Gerstorfer J. Fracture resistance and failure modes of polymer infiltrated ceramic endocrown restorations with variations in margin design andocclusal thickness. J Prosthodont Res 2018; 62:293-297.
[14]. Riyad A, El-Guindy JF, Kheiralla LS. Tensile Bond Strength of (PEEK) vs Lithium DisilicateEndocrown. (An Invitro study). AS Dent J. 2020.
[15]. Foad AM, Hamdy A, Abd el Fatah G, Aboelfadl A. Influence of CAD/CAM Material and Preparation Design on the Long-term Fracture Resistance of Endocrowns Restoring Maxillary Premolars. Braz. Dent. Sci. 2020; 23:1-9
[16]. Elbasty R, Eltannir A, Shaker A. Vertical Marginal Gap Distance and Retention of Different CAD/CAM Ceramic Endocrowns with Two Preperation Designs. Egypt. Dent. J. 2017; 63:755-767.
[17]. SerinKalay T, Yildirim T, Ulker M. Effects of different cusp coverage restorations on the fracture resistance of endodontically treated maxillary

premolars. J Prosthet Dent. 2016;116(3):404-10. doi:10.1016/j.prosdent.2016.02.00

[18]. Adel S, Abo-Madina MM, Abo-El Farag SA. Fracture Strength of Hybrid Ceramic Endocrown Restoration with Different Preparation Depths and Designs. J. Dent. Med. Sci. 2019; 18:17-23.

[19]. Casado BGDS, Leao RDS, Junior JFS, et al. Bond strength between zirconia Y-TZP and resin cements: evaluation of surface treatment, cure mode, and failure types. J. dent health oral disord. 2017; 8:582–586.

[20]. Ahmed MA, Kern M, Mourshed B, Wille S, Chaar MS. Fracture resistance of maxillary premolars restored with different endocrown designs and materials after artificial ageing. J. Prosthodont. Res. 2021; 66: 141-150