IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 21, Issue 10 Ser.6 (October. 2022), PP 51-56
www.iosrjournals.org

Fracture Resistance of Ceramic Endocrown versus Ceramic Overlay With Resin Corein Endodontically Treated Teeth

Maged M. Zohdy, Mostafa M. Nour, WaffaA. Abdel Rahim*
Department of Fixed Prosthodontics
Faculty of Dentistry - Ain Shams University
** Corresponding author: Waffa Ahmed Abdel Fadil Abdel Rahim*

Abstract
Objective:*toevaluate fracture resistance ceramic endocrown versus ceramic overlay with resin core in endodontically treated teeth.*
Materials and Methods:*28 epoxy dies were divided into two groups, group 1 (n14) is restored by ceramic endocrown and the group 2 (n14) is restored by occlussal overlay with resin core. Each group is subdivided into two subgroups with two different computer-aided design/computer-aided manufacturing (CAD/CAM) materials, the subgroup A (n7) with lithium disilicate (Emax) and the subgroup B (n7) with vita enamic.The samples were subjected to 5000 cycles which are equivalent 6 month intraoral aging in two water bath have different temperature (5-55), then it has been done for stimulating the oral cavity environment then all samples were placed in a universal testing machine ' until fracture occurred for fracture resistance testing.*
Results:*there was a significant difference between the fracture resistance of two tested materials. Lithium disilicate had higher value than Vitaenamic.Samples prepared with overlay with resin core had a higher value of fracture resistance than those with endocrown restoration but the difference was not significant.*
Conclusion:*Ceramic overlay with resin core had a higher fracture resistance values than ceramic endocrown in restoring root canal treated teeth, but the difference was not statistically significant. Lithium dislocate ceramics had higher fracture resistance values than using vita enamic in restoring endodonticallytreated teeth.*
Key words: *Fracture resistance, ceramic endocrown, ceramic overlay, resin core, endodontically treated teeth*

Date of Submission: 09-10-2022 Date of Acceptance: 22-10-2022

I. Introduction

During the past 20 years, there have been substantial advancements in the restoration of teeth that have had endodontic treatment. The majority of these modifications are related to the preservation of tooth structure, which has been made possible first and foremost by the growing use of operative microscopes, nickel titanium tools, and most recently cone beam computed tomography. These tools have allowed clinicians to significantly reduce the amount of coronal and radicular hard tooth tissue removed during the process of creating access cavities.(1)

Nowadays, endocrowns, defined as “bonded overlay restorations,” are anchored macro-mechanically to the internal portion of the pulp chamber walls and on the cavity margins whereas micromechanical retention is provided by the use of adhesive cementation.(2)

Moreover, endocrowns have the advantage of preserving tooth structure, reducing the need for auxiliary macroretentive features, and saving the patients and operator time due to fewer clinical steps. (3)

In parallel with the developments and improvements in CAD/CAM, new and varied ceramic materials with different physical, mechanical and aesthetic properties are continually being developed. However, dentists have to consider the biomechanical behavior of these materials in order to make a well-informed decision. [4]

It has been reported that several factors play an important role on the longevity of ceramic restorations, such asthestrength,thickness,compatibilityofthe modulus of elasticity of the ceramics and tooth, and the adaptation of the restorations to the interfacial bonding surface.[5]

Lithium disilicate(LS2)glass-ceramicis ideally suitable for thefabrication of monolithic restorations or veneered restorations in theanterior and posterior region(6). Due to its natural-looking tooth colouring and excellent light-optical properties, this material produces impressiveresults.

Polymer infiltrated ceramic materialis a durable hybrid ceramic that can be processed with efficient computer-aided design/computer-aided manufacturing(CAD/CAM)support. The porous sintered feldspar ceramic block that is infiltrated with polymer does not require a ceramic furnace after being ground out. Instead, it only needs to be finished and polished. This makes one-time chairside treatment possible(7,8).

The use of resin composite liners or base material with a low modulus of elasticity as the first increment has become increasingly accepted over the past few years. [9]

Although some literatures were comparing the fracture resistance of different endocrown restorative materials, there is no enough data about the effect using resin composite as base material with endocrown restorations.

Testing fracture resistance is needed in order to get better choice of material selection as well as value of resin composite in the future.

II. Materials and Methods

The main materials used in the study are presented in Table (1).

1-Teeth selection:

Extracted mandibular first molar, examined under stereomicroscope (magnification x10) to ensure that the tooth is free from caries or crack lines and to make sure the apices were completely formed. Tooth selection was performed according to the following criteria: Tooth was sound, non-carious and non-cracked. Depth of the pulp chamber ranged from 5 to 7 mm measured from the central groove to the pulpal floor using a periodontal probe through the access cavity.

Molar was stored in 5% formal/saline for 2 hours then cleaned and transferred to distilled water to prevent desiccation during storage.

2- Endodontic treatment of teeth:

The canals length of the tooth were determined visually by passing size s 10-K-file into the root canals until being visible at the apical foramen,then working lengths were established 1 mm short from apical foramen

Protaper system was used for root canals treatment as follows:for mesial canal,F2 was used as master file, while F3 were used as a master file for distal canal,sodium hypochlorite was used asirrigant after each file used.

Protaper paper points and guttapercha size F2 was used for mesial canals and F3 for distal canal.Resin based root canal sealant was used then a red hot condenser was used for removal ofthe excess guttapercha.

3- Mounting of the natural tooth in an acrylic resin block:

Mould was fabricated from ready-madepolypropylene tubes of diameter 2.50 Cm and height 6 Cm. Non-shrink epoxy resin material was used for mounting the teeth in mould.A surveyor was used to ensure upright position of teeth in mould.

4-Tooth preparation:

- Pulp chamber was prepared with anatomic configuration of the chamber using intensive kit (internal taper of 8 to 10 degrees)with elimination of any undercuts, any excess guttapercha was removed without touching the pulp floor[10].
- 2 mm occlussal reduction 90 degree (butt margin) using wheel stone
- Replication of the prepared tooth Using epoxy resin, 28 dies were made.The teeth were randomly divided into twogroups according to restorative technique n=14:

a- Endodontically treated mandibular first molar restored with a ceramic endocrownn=14.

b- Endodontically treated mandibular first molar restored with ceramic occlussal overlay with a resin build upn=14.

Table (1): Variables of the study

	Lithium disilicate (Emax)sub group A(L)	**PICN blocks(Vita Enamic) Subgroup(P)**	**Number of the tooth(n28)**
Endocrown (Group (E)	LE (n=7)	PE (n=7)	n=14
Occlussal overlay withresin core(Group (O)	LO (n=7)	PO (n=7)	n=14

5- Pulp chamber modification

For all specimens sand blasting forepoxy dies were done.

The pulp chamber of the endodontically treated teeth was restored as follows;

Half of specimens were restored by SDR bulkfill composite elevating the pulp chamber depth to be 2mm following a depth marked using the servayorand the other half were left without any modification.A digital caliper was used then to check the depth of all pulp chambers after modification.

7 - Restoration fabrication:
Endocrown restoration was fabricated using open cad/cam system which includes the following:
a-Exocad software
b-Indentica blue scanner
c-Vhf milling machine

8- Restoration checking,finishing and polishing:
After milling process is finished,the attachments points and any sharp tips that result from milling procedure were removed.The restoration was carefully cleaned to remove any remnants that affect bonding procedure.

Vita enamic
The restorations were finished by vita enamic polishing set,pre polishing was done by the pink coded polishing tools included in the set (7.000-10.000).High-gloss glass polishing was done by diamond coated gray tools included in the set (5.000-8.000).

Emax
It was done by Diasyntplus – Diapro (EVE)Germany,fine grain diamonds (<60)were used for IPS max cad followed by medium fine diamond polisher then the restoration were cleaned with ultrasound in water with steam jet to remove any residue before crystallization.

9-Restoration adhesive cementation:
Surface treatment of the restoration:

Emax:
Etching of the bonding surface of the restorations was done using 9.5% hydrofluoric acid and gel for 20 seconds, then rinsed thoroughly for another 60 seconds then dried with oil air. The surfaces were then silanized and left to react for 60 seconds.

Vita enamic:
Etching of the bonding surface of the restorations was done using 9.5% hydrofluoric acid and gel for 60 seconds. The restorations were then rinsed thoroughly for another 60 seconds then dried with oil air.The surfaces were then silanized and left to react for 60 seconds.

Cement:
Restorations were cemented to the preparation by using rely x unicem 2 automix resin cement. The cement was applied according to the recommendations of manufacture through applying resin cement to the fitting surface of the restorations and inside the preparations.The applied cement was then lightly thinned with air to avoid its coagulation.

The restorations were placed on their specific preparation by static finger pressure then axially loaded with a 1 kg lead using a specially designed device. The cemented restorations were left under static load for 5 minutes during which they were exposed to a brief high curing for only 2 seconds,the excess cement was removed with a scaler, and then light curing was done for 20 seconds for each side.

10- Thermal cycling of the restoration:
The samples were subjected to 5000 cycles which are equivalent to 6 month intra oral aging in two water bath have different temperature (5-55), it has been done for stimulating the oral cavity environment,dwell time (immersion time)was 20 seconds in each path and the rest time was 10, the total time for each cycles was 50 seconds.

11-fracture resistance testing:
All samples were placed in a universal testing machine until fracture occurred. The specimens were loaded vertically on the central fossa of their occlussal surfaces.
The loading piston was centred along the long axis of the speciments with a 6 mm in diameter steel ball.

Thrust speed of the machine was 0.5 mm/min.The universal system that recorded the breaking loads in Newton (N). Fracture was determined as load suddenly dropped and by acoustic events.

Statistical analysis:

Numerical data were explored for normality by checking the data distribution using Shapiro-Wilk tests. Data showed parametric distribution so; they were represented by mean and standard deviation (SD) values. Two-way ANOVA followed by Tukey's post hoc test was used to study the effect of different tested variables and their interaction. Comparison of main and simple effects were done utilizing multiple t-tests with Bonferroni correction. The significance level was set at p ≤ 0.05. Statistical analysis was performed with R statistical analysis software version 4.1.3 for Windows.

III. Results

1. Effect of different variables and their interaction:

Effect of different variables and their interaction on fracture resistance (N) were presented in table (2).Only material had a significant effect on fracture resistance (p<0.001).

Table (2): Effect of different variables and their interactions on fracture resistance (N)

Source	Sum of squares	df	Mean square	f-value	p-value
Design	218713.71	1	218713.71	3.93	**0.071ns**
Material	1642783.15	1	1642783.15	29.5	**<0.001***
Design*Material	2025.06	1	2025.06	0.04	**0.852ns**

df=degree of freedom*; significant ($p \leq 0.05$) ns; non-significant (p>0.05)

2. Main effects:

A-Effect of design:

Mean and standard deviation (SD) values of fracture resistance (N) for different designs.

Overaly (1329.85±442.57) had a higher value than endocrown (1096.01±366.85) yet the difference was not statistically significant (p=0.071).

B-Effect of material:

Mean and standard deviation (SD) values of fracture resistance (N) for different materials.

Emax (1533.36±315.04) had significantly higher value than Vita Enamic (892.50±166.59) (p<0.001).

3. Interactions: (Interactions are not necessary since they are not significant in the two-way ANOVA)

Mean and standard deviation (SD) values of fracture resistance (N) for different designs and materials.

A- Effect of design:

- **Emax:**
  Overaly (1661.52±366.80) had a higher value than endocrown (1405.19±230.73) yet the difference was not statistically significant (p=0.282).
- **Vita Enamic:**
  Overaly (998.17±170.64) had a higher value than endocrown (786.83±76.58) yet the difference was not statistically significant (p=0.065).

B- Effect of material:

- **Overlay:**
  Emax (1661.52±366.80) had significantly higher value than Vita Enamic (1405.19±230.73) (p=0.017).
- **Vita Enamic:**

Emax (998.17±170.64) had significantly higher value than Vita Enamic (786.83±76.58) (p=0.002).

IV. Discussion

Endodontically treated teeth more susceptible than vital teeth to biomechanicalfailure because of the access preparation[11],endodontically treated teeth undergo increased cuspal deflection during loading and the delayed recovery upon removal of the load leading to crown fractures[12].

Endocrown which is a single partial restoration could be considered as a good alternative for restoring molars having large coronal destruction and presenting endodontic treatment difficulties [13].

The main purpose of our study was to assess the effect of two CAD/CAMmaterials (Lithium disilicate ceramic emax and polymer infiltrated ceramic network vitaenamic), two intrapulpal extensions:4mm (normal pulp cavity depth) and 2mm (elevated pulp cavity depth).

Convitionaldesign of endocrown generate high stress values with a negative influence in the biomechanical behaviour of the restorative system when used to replace dentin. [14]

The resin buildup better distributes or absorbs the stress caused by the force applied to the tooth than a ceramic monoblockEndocrown would without this resin layer.

Ceramic materials are considered to be viable alternatives because of their superior esthetics, biocompatibility, resistance towear, and similarity in coefficient of thermal expansion with that observed for dental structure.[15]

Endodontic treatment was done for extracted molar, mounting of the natural tooth in an acrylic resin block.

Tooth was prepared using intensive kit with internal taper 8 to 10 degrees with elimination of any undercuts [72], 2 mm occlussal reduction 90 degree (butt margin) using wheel stone.

Duplication of prepared endodontically tooth in 28 epoxy dies (artificial teeth) provide standardized preparation and identical physical qualities of materials used in comparsion to natural teeth.[16]

Two pulpal extensions have been done in our study.One group with a 4mm pulpal extenstion and second one with 2mm pulpal extension achieved by filling the pulp chamber with a2 mm resin composite.

Fabrication endocrown restorations were standardized by using CAD/CAM technology via adjusting the parameters in EXOCAD software.All endocrowns were polished and finished according to the manufacturer's recommendations. Full anatomic restorations were used,because it has been reported that these may allow the restorations to behave in a manner that potentially represents the clinical situation more closely than ceramic discs.[17]

Self –Adhesive Resin cement was used for cementation of the endocrowns to the prepared teeth, also it is recommended for bonding to tooth structure as it was reported to increase their fracture resistance [18]; being a dual cured cement, its self –polymerization component is desirable for the thick endocrowns which might not allow the light to penetrate through its full thickness [19].

Testing the fracture resistance of a ceramic material in vitro is a perquisite for clinical application.Static loading to fracture is a test that is most commonly used to give an indication of a material and a type of restoration suitability as a viable treatment option for clinical situations[20].

However,it can only show the strength of a restoration immediately after binding and most likely it shows values of fracture resistance that are not indicative of the long –term success of the restoration[21].

All specimens were tested using vertical loads to simplify the result analysis, so clinical implications of the current study must be limited to that application. The data of the fracture resistance in this study should be taken relatively not as absolute ones, and the extrapolation of this data to the clinical situation must be considered carefully[22].

Regarding the results of our study,fracture resistance values of the endocrowns using two CAD/CAM ceramic materials,lithumdisilicate (IPS-emax) is higher than vita enamic this is due to the high mechanical properties of this material. The microstructure of the LD includes needle-like particles with different orientations. Its elastic modulus (~64 GPa) and particle size (from 0.5 to 4 μm). The higher crystalline content (approximately 70% by volume) and densely packed crystalline structure of LD in addition to an elongate grain structure is well suited to providing a respectable toughness by inhibiting crack propagation and increase the mechanical strength. Even if cracks were to form, they would become trapped within the crystals, potentially preventing further propagation[23].

while fracture strength of vitaenamic is low this could be attributed to the relatively low mechanical properties of this material including low flexural strength (150-160 MPa) and low fracture toughness (1.5 MPa m1/2). Another possible factor may be the hybrid nature of this material as it is composed of interconnected networks of ceramic and polymer, which leads to different rates of ablation for ceramic and polymer during the grinding and polishing processes, that may result in microcracks in the network boundaries, and this is assumed to decrease the mechanical properties of the material[24]. Moreover, in a hybrid material, failure could be initiated from any weak point of the microstructure, like the polymer in a polymerinfiltrated ceramic[25].

This was in agreement with***Bilkhair***[26] who compared the fracture strength of monolithic crowns fabricated from hybrid dental ceramic with those fabricated from lithium disilicate and feldspathic ceramics. They found that the fracture strength of crowns fabricated from hybrid dental ceramic was lower than that of lithium disilicate crowns.

This finding is against **Zhu et al**in their finite element analysis study, they proved that although using a high elastic modulus material like zirconia or lithium dislocates results in less deformation to load but all the stress where transferred to the remaining teeth structureand might lead to further tooth fracture in the future,while the use of a law modulus of elasticity material as leucite material or even composite resin lead to more stress distribution and less stress concentration leading to less tooth fracture and longer survival rate [27].

Concerning the effect of intrapulpal depth, the 2mm intapulpal depth showed higher fracture resistance Since high stiffness materials like ceramics generate high stress values with a negative influence in the biomechanical behaviour of the restorative system when used to replace dentin, the use of low stiffness materials as composite resins that accompany the natural flexure of the dentin, reduce the stress. This type of materials seems to be a reliable strategy to generate low stress values when used a build-up[28]. Moreover, decreasingthe pulpal extension into the pulp chamber would decrease the lever arm of the endocrowns.[29]

This was in agreement with in an in vitro study made by **Magne et al**. it is concluded that the use of a small composite resin build-up may be useful because it can provide enhanced geometry, remove undercuts from the endodontic preparation and facilitate provisionalization when it is needed[30].

Moreover, the results were against the finite element study by **Aboel–Fadland Desoky[31],**where more stress were encountered on using 2mm composite seal to the pulpchamberwhich was attributed to the increase in the number of interfaces.

V. Conclusion

Ceramic overlay with resin core had a higher fracture resistance values than ceramic endocrown in restoring root canal treated teeth, but the difference was not statistically significant. Lithium dislocate ceramics had higher fracture resistance values than using vita enamic in restoring endodontically treated teeth.

References:

[1] Chenug W.A review of the management of endodontically treated teeth: post, core and the final restoration journal of the American Dental Association 136(5):611-619.
[2] Biacchi G. R., Basting RT. Comparison of fracture strength of endocrowns and glass fiber post-retained conventional crowns. Oprative Dentistry.2012;37:130- 136.
[3] Mörmann WH, Bindl A, Luthy H, Rathke A. Effects of preparation and luting system on all –ceramic computer-generated crowns. Int J prosthodont 1998; 11(4):333-9.
[4] Kanat-Erturk; Saridag S; Koseler E; Helvacioglu-Yigit D; Avcu E; Yildiran-Avcu Y. Fracture strengths of endocrown restorations fabricated with different preparation depths and CAD/CAM materials. Dental material journal.2018; 1-10.
[5] Kelly JR. Clinically relevant approach to failure testing of all ceramic restorations. J Prosthet Dent 1999; 81: 652-661.
[6] Gohring TN, Gallo L, Luthy H. Effect of water storage, thermocycling, the incorporation and site of placement of glass-fibers on the flexural strength of veneering composite, Dent Mater 2005;21(8): 761 -72.
[7] Leung BT, Tsoi JK, Matinlinna JP, Pow EH. Comparison of mechanical properties of three machinable ceramics with an experimental fluorophlogopite glass ceramic. J Prosthet Dent 2015;114:440–6.
[8- Helvey G. The expansion of millable materials: new additions to the market increase patient care-options. Inside Dent Technol 2014;5:58–71.
[9] Kwon OH, Kim DH, Park SH. The influence of elastic modulus of base material on the marginal adaptation of direct composite restoration.Oper Dent.2010;35:441–7.
[10] Shahin R, Tannous F, Kern M. Inlay-retained cantilever fixed dental prostheses to substitute a single premolar: Impact of zirconia framework design after dynamic loading. Eur J Oral Sci. 2014;122(4):310–6.
[11] Sagsen B, Aslan B. Effect of bonded restorations on the fracture resistance of root filled teeth. IntEndod J 2006;39:900- 4.
[12] Huang T, Schilder H, Nathanson D. Effects of moisture content and endodontic treatment on some mechanical properties of humandentin. J Endod 1992; 18:209-15.
[13] Dogui H. An alternative approach for restoring endodonticallytreated molars with large coronal destruction.Hendawi J 2018; 1581952.
[14] Zarone F, Sorrentino R, Apicella D, Valentino B, Ferrari M, Aversa R, et al. Evaluation ofthe biomechanical behavior of maxillary central incisors restored by means of endocrown compared to a natural tooth: A 3D static linear finite elements analysis. Dental Materials2006:22:1035-44.
[15] Ritter A, Baratieri L. Ceramic restorations for posterior teeth:guidelines for the clinician. J Esthet Dent 1999;11:72-8.
[16] Nawrocka A, Lukomska-Szymanska M. Extracted human teethand their utility in dental research. Recommendations on properpreservation: A literature review. Dent Med Probl 2019; 56: 185-9.
[17] Al-Makramani BMA, Razak AAA, Abu-Hassan MI. Evaluationof load at fracture of ProceraAllCeram copings using differentluting cements. J Prosthodont 2008; 17: 120-4.
[18] Behr M, Rosentritt M, Mangelkramer M, Handel G. Theinfluence of different cements on the fracture resistance andmarginal adaptation of all-ceramic and fiber-reinforced crowns.Int J Prosthodont 2003; 16: 538-42.
[19] Blatz MB, Sadan A, Kern M. Resin-ceramic bonding: a reviewof the literature. Journal of Prosthetic Dentistry 2003; 89: 268-74.
[20] Forberger N, Gohring TN. Influence of the type of post and core on in vitro marginal continuity, fracture resistance, and fracture mode of lithium disilicate –based all – ceramic crowns. J Prosthet Dent 2008; 100:264-73.
[21] Skouridou N, Pollington S, Rosentritt M, Tsitrou E. Fracture strength of minimally prepared all-ceramic CEREC crowns after simulating 5 years of service. Dent Mater 2013; 29: e70-7.
[22] Zahran M, El-Mowafy O, Tam L, Watson PA, Finer Y. Fracturestrength and fatigue resistance of all-ceramic molar crownsmanufactured with CAD/CAM technology. J Prosthodont 2008;17:370-7.
[23] Faria AC, Rodrigues RC, de Almeida Antunes RP, de Mattos MG, Riberio RF. Endodontically treated teeth: characteristics and considerations to restore them. J Prosthodont Res2011;55(2):69-74.
[24] Eraslan O., Eskitascioglu G., Belli S. Conservative restoration of severely damaged endodontically treated premolar teeth: a FEM study. Clinical Oral Investigations 2011;15:403–408.
[25- Chang CY, Kuo JS, Lin YS, Chang YH.Fracture resistance and failure modes of cerecendo-crowns and conventional post amd core-supported CEREC crowns.JDentSci 2009;4(3):110- 7.
[26] Bilkhair A. Fatigue behaviour and failure modes of monolithic CAD/CAM hybrid-ceramic and all-ceramic posterior crown restorations (Doctoral dissertation, Dissertation, Universität Freiburg, 2014).
[27] Zhu J,.Rong& Wang &, Cao X. Influence of remaining tooth structure and restorative material type on stress distribution in endodontically treated teeth: a finite element analysis. Journal of prosthtic dentistry 2017;117:646-55.
[28] Krejci I, Duc O, Dietschi D, de Campos E.Marginal adaptation, retention and fracture resistance of adhesive composite restorations on devital teeth with and without posts.Oper Dent 2003;28(2);127-35.
[29] Skupien JA, Luz MS, Pereira-Cenci T. Ferrule Effect: A Meta-analysis. JDR Clin Trans Res 2016; 1: 31-9.
[30] Magne Y, Bianchi A.A., Ghiggi P.C., Mota E.G., Borges G.A., Júnior L.H. and Spohr A.M.: Influence of restorative techniques on fracture load of endodontically treated premolars. Stomatologija 2013; 15:123-8.
[31] Aboel-Fadl AK, Adelel-Desoky M. Influence of endocrown pulpal extension on stress distribution in endodontically treated maxillary premolars. a three-dimensional finite element analysis. Dental Journal 1953; 63:2017.