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Comparison of Fracture Resistance of Conventional Full Crowns with Endocrowns On Endodontically Treated Teeth: An In-Vitro Study

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Abstract

Aim: The goal of this in-vitro study was to evaluate the resistance to fracture of conventional full crowns versus Endocrowns placed on root canal treated teeth. (endodontically treated teeth)

Materials and methodology: A total of thirty-six extracted human`s permanent mandibular molars were randomly assigned to four groups with nine specimens each. **Group-1** included Conventional Metallic crowns (CMC), **Group-2** included Conventional Porcelain Fused Metallic crowns (CPFMC), **Group-3** comprised Complete Metallic Endocrowns (FME), and consisted of Porcelain Fused Metallic Endocrowns (PFME).

Before conducting the mechanical fracture test, teeth roots were encapsulated with a thin polyether impression material layer measuring 0.2 mm, after which the samples were embedded in an auto-polymerizing acrylic resin block up to the cemento-enamel junction (CEJ) level.

Results: Samples underwent fractured deformation under compressive-axial load applied on functional cuspal inclination. The recorded values marked as maximum compressive-axial load for each tooth sample collected during evaluation. Resulting data was organized into tables and evaluated statistically using unpaired t-test, one-way ANOVA with post-hoc Bonferroni correction which demonstrated a strong statistically significant difference among all the groups (p value $\leq 0.001^*$).

Conclusion: The present study concluded that Endocrowns had exhibited minimum internal stress distribution and maximum fracture resistance and were in restorable state as opposed to conventional crowns.

Keywords: Endocrowns; teeth with root canal therapy; fracture resistance, endodontically treated teeth.

1. Introduction

Clinical success of endodontic treatment relies on a broad array of clinical procedures depending on the type and quality of coronal restorations.[1] The endodontically treated teeth are weakened and have an increased risk of biomechanical failure due to extensive tooth structure loss[19] i.e., surrounding dentin and pulp tissue.[2] To facilitate their survival, preparation designs for coronal restorations have been modified to more conservative due to improvements in adhesive dentistry, which involves addition of some mechanical retentive features such as undercuts, grooves, or boxes.[1]

Among many of the conservative approaches, Endocrowns are one of the coronal restorations used because they are the most preferred feasible alternative for the rehabilitation of severely compromised endodontically treated teeth (ETT).[2] They provide a Monoblock restoration that combines both core and crown.

Both of the cavity margins in which the coronal part resides as well as the inner pulp chamber walls are involved in the apical projection that fills the pulp chamber space, and possibly the entrances of the root canals.[3] It is found to provide access sealing into the root canal and seal away from bacterial micro-leakage that may affect the successful long-term prognosis of an endodontically treated tooth.[4] It acts on a bonded biomimetic reconstruction.

The clinical procedure of post and core crowns is done conventionally.[19] An Endocrown is a full coverage restoration with a circumferential butt joint margin and retentive feature which extends into the pulp chamber space.[5, 20]

Usually, it is designed using CAD CAM techniques.[6] Creating a complete crown restoration such as Endocrown (Adhesive Endocrown) on a metal core or filling is beneficial to restore extensively destructed endodontically treated teeth.[7]

Hence, the objective of this research was to study the fracture resistance of Endocrowns and full crowns in an endodontically treated teeth under compressive-axial load (CAL) forces with Universal Testing Machine (UTMI) and analyze the cracks under dental operating microscope.[19]

Materials and methodology

Thirty-six permanent mandibular molars with fully formed apices (closed apex was ascertained radiographically) that were caries-free or had minimal carious teeth with no cracks and no furcation, with complete four walls, with the crown up to 2 mm coronal to the Cemento-Enamel junction (CEJ) and those extracted due to Endo-Perio lesions were used for the study. Thereafter, the teeth were debrided of soft tissue, dental calculus, and stains with ultrasonic scaler.

Later, were disinfected with 5% sodium hypochlorite for 30 minutes and rinsed off the debris in tap water and stored in physiological saline.

The samples were placed randomly into four groups (n=9). **Group 1** (CMC): Traditional Metallic crowns, **Group 2** (CPFMC): Traditional Porcelain Fused Metallic crowns, **Group 3** (FME): Full Metallic Endocrowns, **Group 4** (PFME): Porcelain Fused Metallic Endocrowns.

Access opening was performed with endo-access diamond coated burs (Dentsply) and endo-Z burs (SS White) to achieve straight line access. Coronal aspect of the teeth was shaped using Gates Glidden drills (Mani) = [size 3# to 1#] to widen the canal orifices. The canals were initially instrumented with the set of K-files (Mani) = [no-8 to no-15], by manual technique with normal saline and 5.25% NaOCl as irrigant, then working length determination with the apical size of 20-k file was set to 50 K- file for the purpose of patency of the canal and conformation using Radiovisiography (RVG). Biomechanical preparation [BMP] was done by using protaper file system (Dentsply) up to F2. Canals were irrigated with 10ml 17% EDTA for 3 min, to desmooth smear layer and rinse lastly with 20 ml physiological saline solution.Obturation with lateral condensation technique was done.

Light cure composite resin was used to complete post-endodontic restoration.

Specimens were sectioned perpendicular to long axis of roots around 2 mm above cemento-enamel junction of tooth structure. [as standardization of samples]. Further the conventional full crowns and Endocrowns preparation with pulpal extension was maintained at 4mm from Cemento-enamel junction (CEJ) in the pulpal floor. Both groups were then bonded with their respective crowns, which were fabricated from the Unique dental Lab-Bangalore, using Adhesive GIC (Adper Single-Bond Plus Adhesive, 3M ESPE).

Before the mechanical fracture test, the roots of the teeth were covered by a polyether impression material (L DuoSoft, 3M ESPE) with a 0.2 mm thickness to simulate the PDL, and the samples were embedded in an auto-polymerizing acrylic resin block (Pyrax® Acryl-Hi, Intellodent, Germany) up to the level of CEJ. Functional cuspal inclinations were submitted to the samples on the compressive-axial forces. The tooth specimen at a certain point breaks and the obtained values were noted as maximum compressive-axial load for the individual tooth specimen.

The recorded data were organized in a table and statically analyzed. All the samples were exposed to dye penetration using methylene dye to confirm the cracks that were confirmed using dental operating microscope. X-rays were then taken to grade the fracture lines of tooth specimens.

RESULTS:

The results thus obtained were statistically analyzed and compared using unpaired t-test, one-way analysis of variance (ANOVA) and post-hoc Bonferroni test with the help of I.B.M SPSS software for windows, version 20, Armonk, NY: I.B.M Corp.The Mean force distribution between the groups obtained after axial loading using Universal Testing Machine (UTM) was presented as in Table 1. One-way analysis of variance (ANOVA) was also carried out and f-value obtained i.e., 65.61 and highly significant difference was observed (p = 0.00) (Table 2).Comparisons between and within groups were performed using Bonferroni multiple comparison test (Table 3). Statistically significantly different from one another was all the groups.

Table 1: Distribution of Mean Force (in Newton) across the groups

	n	Minimum*	Maximum**	Mean	SD
Group 1	9	1693.54	2189.27	1873.231	151.39
Group 2	9	2287.81	2909.72	2660.122	201.38
Group 3	9	2106.11	2418.59	2257.749	104.49
Group 4	9	2566.62	3421.28	3029.005	250.15

n = number of Samples, SD = Standard Deviation, (*) = Minimum compressive-axial load values, (**) = Maximum compressive-axial load values.

Table 2: Comparison of Force (in Newton) among the groups with ANOVA

	F value	p value
Force (in Newton)	0.00*	0.00*

p –Probability value; P<0.001-Significantly High ; P<0.05 significant; P>0.05-Not significant

Table 3: The intra-group and inter-group comparisons made using Bonferroni multiple comparison test

		Mean diff	p value
Group 1	Group 2	-786.89	000*
	Group 3	-384.51	001*
	Group 4	-1155.77	000*
Group 2	Group 3	-402.37	.000*
	Group 4	-368.88	.001*
Group 3	Group 4	-771.25	.000*

p –Probability value; P<0.001-Significantly High; P<0.05 significant; P>0.05-Not significant

Discussion

Endocrowns can be considered a conservative approach towards the reconstruction of Endodontically treated molar teeth, especially in compromised remaining tooth structure cases, short clinical crowns, flared root canals, and minimal interocclusal space.[8] This specific restoration technique utilizes the pulp chamber space to provide macro-mechanical retention as well as micro-retention by adhesive cementation there by aiding proper reconstruction from a biomechanics standpoint as well as contributing significantly towards affecting the success rate of final coronal restorations.[9]

The major objective of Endocrown restoration is to conserve the current tooth structure, as single-crown or post-core restorations were difficult in conserving in clinical situations. In clinical studies, Endocrowns were used mostly in teeth with small coronal tooth structure left, where it would be difficult to build up a ferrule, but margins were mostly equigingival.[10]

Not withstanding this, most in-vitro research utilized resin ceramic or lithium disilicate ceramics to fabricate Endocrowns.[11] A probable reason for this is that the resin ceramic has an elasticity modulus comparable to dentin and thus will distribute occlusal loads more evenly across the bonded surface of posterior teeth, improving fracture resistance while reducing catastrophic failure. The results of most in vitro studies on Endocrown CAD-CAM restorations were positive.[12]

In the present study Endocrowns preparation with the pulpal extension was maintained at a height of 4mm from Cemento-enamel junction (CEJ) in the pulpal floor.

Moreover, Dartora et al.[12] had compared biomechanical behavior of endodontically treated teeth restored with varying extensions of Endocrowns within the pulp chamber; the study concluded that extending Endocrown restorations to greater dimensions provided better mechanical behavior.[12]

Most of the extension with 5-mm or 4-mm areas showed less load and better stress distribution in functional loading as compared with 1 mm extension area that experienced poor fracture resistance under functional loading and had a poor chance for equal stress distribution.[12]

Shin et al. reported Endocrown with 4 mm cavity depth had more marginal and internal volume than 2 mm cavity depth.[13]

In the presented study: The full metal routine crown structure showed non-restorable fractures and cracks extending into the furcation area.The Porcelain Fused Metallic traditional crown structure showed non-restorable bulk fractures as well as metal-core sub-structure fractures and cracks extended to furcation area.The full metal Endocrown structure showed restorable fractures with limitation of prosthetic crown crack.The Porcelain Fused Metallic Endocrown structure showed restorable fractures with limited prosthetic crown damage.Group 4 [Porcelain Fused to Metal (PFM) Endocrowns] reported a very high statistical significant difference (p value = .000*) in reporting higher fracture resistance compared to Groups 1, 2 and 3. Group 1 [Full Metallic Conventional Crowns] reported a statistical significant difference in reporting lower fracture resistance compared to Groups 2, 3 and 4. Groups 1, 2 [Conventional crown groups] reported non-restorable fractures.Groups 3 and 4 [e.g. endocrown groups] had restorable fractures. The mean difference between Group 1a and Group 1b -786.89; Group 1a and Group 2a -384.51; Group 1a and Group 2b -1155.77 (noted as -1155.77 in group 1b); Group 1b and Group 2a -402.37; Group 1b and Group 2b -368.88; and Group 2a and Group 2b -771.25 demonstrating that we had highly statistically significant difference between group (p value ≤ 0.001*).

PFM Endocrowns demonstrated higher resistance to fracture and demonstrated restorable fracture on test specimens, explaining these shows large amount of internal stress distribution due to larger surface-area contacts compared to Metal conventional crowns. Metal conventional crowns demonstrated lower resistance to fracture and with non-restorable fracture of crown and root on test specimens.

According to Dejak B et, al.[14] in-vitro finite element analysis study suggested that Endocrown technique produces less internal stress forces and less crack propagation than post and core supported full coverage restorations.[14]

According to the present study, the crack propagation test by the methylene dye penetration test, because it pools much better [pooling tendency] and this dye is very dark and also it is with the low toxicity and economical. In the overall result, when Endocrowns were compared with the standard crowns, Endocrowns had shown no cracks on the root surface. PFM Endocrowns and full metal Endocrowns showed restorable fractures, showing minimal cracks confined to prosthetic crowns alone compared to PFM and full metal standard crowns showing non-restorable fractures, where cracks extended up to root surfaces.

According to Elashmawy Y et, al.[15] Endocrowns with different materials after fracture loading will have different failure modes like restorable or non-restorable fracture.[15] Compared to fracture loading of the traditional Endocrown preparations, the results of this study are similar to that of Biacchi et al.[9] who reported a median failure of an Endocrown of approximately 674 N.[9]

The outcomes on the present study are better than those reported by Ghoul W. E. et al.[16] which Endo crown failure loads of 2914 N and El-Damanhoury et al. [17] report a mean fracture load of their lithium disilicate material, it was 1368 N. Similarly, Gresnight et al18 also obtained failure values smaller than the current study. However, their outcomes differ slightly because they used different force vectors to assess failure load, stability and fracture.[16 17]

The main clinical advantage in doing Endocrowns in clinical situations like, an ETT with minimal retention leading to frequent normal crown dislodgment and challenging clinical situations, like highly destructed crown anatomy and constricted or calcified radicular canals where post-&-cores are difficult for clinician.[8] Although the key disadvantages of application of Endocrowns is, in class-II clinical RCT situations there are no evidence-based end results and if in the case of retreatment it is very difficult to remove the Endocrowns or perform Re-RCT through the Endocrowns. Also, in-vitro and in-vivo studies must be carried out for better insight and long-term prognosis of Endocrown restorations in various challenging clinical situations.[12 13]

Conclusion

The present study can be concluded as Endocrowns had shown least intra-crown stress distribution, and highest fracture resistance in comparison to the traditional crowns.

Overall, the PFM and Metal Endocrowns were restorable in contrast to PFM and Metal non-restorable conventional full crowns.

Under the preview of the current research, an in-vitro study is incapable of mimicking all the oral environmental conditions and additional studies have to be conducted with more specimens as well as by applying multiple techniques so that the life span of Endodontically treated teeth can be increased.

References

1. Guo J, Wang Z, Li X, Sun C, Gao E, Li H: Comparison of fracture resistance of endodontically treated mandibular premolars restored by Endocrowns and glass fiber post-core retained metal ceramic crowns. J Adv Prosthodont. 2016;8(6):489-93.
2. Tikku AP, Chandra A, Bharti R: Full cast crowns necessary after endodontic treatment in posterior teeth? J Conserv Dent. 2010;13(4):246-8.
3. Biacchi GR, Mello B, Basting RT,et al: The Endocrown: an alternative approach for restoring extensively damaged molars. J Esthet Restor Dent. 2013;25(6):383-90.
4. Shelley A. Restoration of Endodontically-Treated Posterior Teeth. Prim Dent J. 2017;6(1):54-61.
5. Sevimli G, Cengiz S, Oruc MS. Endocrowns: review: J Istanb Univ Fac Dent. 2015;49(2):57-63.
6. Irmaleny Z, Zuleika, Ardjanggi S, Mardiyah AA, Wahjuningrum DA: Endocrown Restoration on Post endodontics Treatment on Lower First Molar. J Int Soc Prev Community Dent. 2019;9(3):303-10.
7. Dogui H, Abdelmalek F, Amor A, Douki N: Endocrown: An Alternative Approach for Restoring

Endodontically Treated Molars with Large Coronal Destruction. Case Rep Dent. 2018; 2018:1581952.
8. Al-Omiri MK, Mahmoud AA, Rayyan MR, Abu-Hammad O: Fracture resistance of teeth restored with post-retained restorations: an overview. J Endod. 2010;36(9):1439-49.
9. Biacchi GR, Basting RT:Comparison of fracture strength of Endocrowns and glass fiber post-retained conventional crowns. Oper Dent. 2012;37(2):130-6.
10. Bindl A, Richter B, Mormann WH: Survival of ceramic computer-aided design/manufacturing crowns bonded to preparations with reduced macro retention geometry.Int J Prosthodont. 2005;18(3):219-24.
11. Dartora G, Rocha Pereira GK, Varella de Carvalho R, Zucuni CP, Valandro LF, Cesar PF, et al:Comparison of lithium disilicate glass-ceramic or polymer-infiltrated ceramic networks endocrowns and direct composite resin restorations: fatigue behavior and stress distribution. J Mech Behav Biomed Mater.2019; 100:103401.
12. Dartora NR, de Conto Ferreira MB, Moris ICM, Brazao EH, Spazin AO, Sousa-Neto MD, et al: Effect of Intracoronal Depth of Teeth Restored with Endocrowns on Fracture Resistance: In Vitro and 3-dimensional Finite Element Analysis. J Endod. 2018;44(7):1179-85.
13. Shin Y, Park S, Park JW, Kim KM, Park YB, Roh BD: Evaluation of the marginal and internal discrepancies of CAD-CAM Endocrowns with various cavity depths: An in vitro study. J Prosthet Dent. 2017;117(1):109-15.
14. Dejak B, Mlotkowski A: 3D-Finite element analysis of molars restored with Endocrowns and posts during masticatory simulation. Dent Mater. 2013;29(12): e309-17.
15. El-Shmawy 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.
16. Ghoul WE, Ozcan M, Tribst JPM, Salameh Z:Fracture resistance, failure mode and stress concentration in a modified Endocrown design. Biomater Investig Dent. 2020;7(1):110-9.
17. El-Damanhoury HM, Haj-Ali RN, Platt JA:Fracture resistance and microleakage of Endocrowns utilizing three CAD-CAM blocks. Oper Dent. 2015;40(2):201-10.".
18. Gresnigt MM, Ozcan M, van den Houten ML: Fracture strength, failure mode of resin composite Endocrowns subjected to axial and lateral forces. Dent Mater. 2016;32(5):607-14
19. FRACTURE RESISTANCE OF COMPUTER AIDED ENDO- CROWNS VERSUS CONVENTIONAL CORE-SUPPORTED COMPUTER AIDED FULL CROWNS By Mohammad M Rayyan and Ahmed Hussien []IAJD Vol. 10 – Issue 2]
20. Endocrown Restorations on Endodontically Treated Premolars Teeth: A Review Ahmad Mahdi Abdulridha Alkhafaji 1*, Sara Valizadeh2 Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 18606 - 18614 Received 25 April 2021; Accepted 08 May 2021.