Original Research Paper

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Influence of Cavity Design and Fabrication Technique on Fracture Resistance of PFM Endocrowns in Endodontically Treated Mandibular Molars: An In Vitro Study

Abstract:

Background: Endodontically treated teeth (ETT) are structurally weakened due to loss of tooth structure and altered biomechanical properties. Restoration of such teeth remains a clinical challenge. Endocrowns have emerged as a conservative alternative that utilizes adhesive bonding and intracoronal retention. However, factors such as cavity design and fabrication technique significantly influence their fracture resistance.

Materials and Methods: Forty extracted human mandibular molars were selected, cleaned, and standardized. Endodontic treatment was performed using conventional techniques. The samples were divided into four groups (n=10) based on cavity design (conventional and buccal extension) and fabrication technique (conventional impression and CAD/CAM). PFM endocrowns were fabricated accordingly and cemented using glass ionomer cement. Fracture resistance was evaluated using a universal testing machine under compressive load. Statistical analysis was performed using one-way ANOVA and Tukey post hoc test ($p < 0.05$).

Results: The buccal extension CAD/CAM group showed the highest fracture resistance (1009.50 ± 9.48 N), followed by normal CAD/CAM (951.45 ± 11.18 N), buccal extension impression (687.92 ± 9.93 N), and normal impression groups (553.05 ± 10.77 N). The differences were statistically significant ($p = 0.000$).

Conclusion: Both cavity design and fabrication technique significantly influence fracture resistance. Buccal extension combined with CAD/CAM fabrication provides superior biomechanical performance and may be recommended for clinical application.

Keywords: Endocrown; Fracture resistance; CAD/CAM; Porcelain-fused-to-metal; Cavity design; Endodontically treated teeth

Introduction:

Endodontically treated teeth (ETT) are biomechanically compromised due to the loss of structural integrity following caries removal, trauma, and endodontic access preparation (1,2). The reduction in fracture resistance is primarily attributed to the loss of marginal ridges and pericervical dentin, which play a critical role in maintaining tooth stiffness (2). Consequently, restoration of ETT requires materials and techniques that can effectively reinforce the remaining tooth structure.

Traditionally, post and core restorations have been employed to rehabilitate such teeth. However, these systems often require extensive removal of radicular dentin, thereby weakening the root and increasing the risk of catastrophic root fractures (3). In contrast, adhesive restorative approaches aim to preserve tooth structure and improve stress distribution.

Endocrowns have emerged as a conservative and biomimetic alternative for restoring ETT. They utilize the pulp chamber for macromechanical retention and adhesive bonding for micromechanical retention, eliminating the need for intraradicular posts (4). This design enables the restoration to

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function as a monoblock unit, resulting in more uniform stress distribution and reduced incidence of unfavorable fracture patterns (5).

Various restorative materials, including lithium disilicate, zirconia, and composite resins, have been used for fabrication of endocrowns due to their favorable mechanical properties (6). However, porcelain-fused-to-metal (PFM) restorations continue to be widely used in posterior teeth because of their superior strength, durability, and resistance to occlusal forces (7).

The success of endocrowns is influenced by several factors, among which cavity design and fabrication technique are of paramount importance. Modified cavity designs, such as buccal extensions, increase the bonding surface area and improve stress distribution, thereby enhancing fracture resistance (8). Similarly, CAD/CAM fabrication techniques provide improved marginal adaptation, reduced internal defects and better structural homogeneity compared to conventional methods (9).Despite the growing popularity of endocrowns, limited literature exists regarding the combined effect of cavity design and fabrication technique on the fracture resistance of PFM endocrowns. Therefore, the present study was undertaken to evaluate and compare the fracture resistance of PFM endocrowns with different cavity designs and fabrication techniques in endodontically treated mandibular molars.

Materials And Methods:

Study Design:

This in vitro experimental study was conducted in the Department of Conservative Dentistry and Endodontics.

Sample Selection:

Forty freshly extracted human mandibular molars of similar dimensions, free from cracks, cariesand restorations, were selected. The samples were cleaned and stored in thymol solution to prevent dehydration and microbial growth.

Standardization of Samples:

All teeth were decoronated or standardized to a uniform length of approximately 20 mm to ensure uniform distribution of forces during testing.

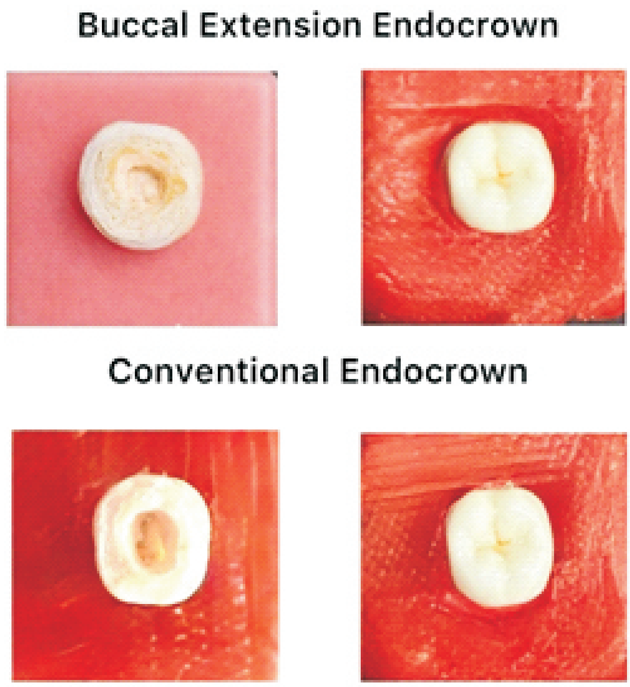
Endodontic Procedure:

Access cavities were prepared using high-speed burs. Working length was determined and cleaning and shaping were performed using K-files. Irrigation was carried out using sodium hypochlorite followed by EDTA to remove the smear layer and enhance bonding conditions. The canals were obturated using a single cone technique with gutta-percha and sealer.

Grouping of Samples:

Samples were randomly divided into four groups (n = 10):

- **Group 1:** Normal Impression
- **Group 2:** Normal CAD/CAM
- **Group 3:** Buccal Extension Impression
- **Group 4:** Buccal Extension CAD/CAM



Cavity Preparation:

- Conventional endocrown preparation was done following standard guidelines.
- Buccal extension design included additional extension on the buccal surface to increase bonding surface area and improve retention.

Fabrication of Endocrowns:

PFM endocrowns were fabricated using:

- Conventional impression technique
- CAD/CAM technique for digital scanning and fabrication

CAD/CAM fabrication ensured improved accuracy, marginal fitand uniformity of material.

Cementation Procedure:

Prior to cementation, the prepared tooth surfaces were cleaned and dried. The internal surface of the restoration was also cleaned to remove any contaminants. Glass ionomer cement was mixed according to the manufacturer's instructions and applied to the internal surface of the restoration.

The endocrowns were then seated onto the prepared tooth with uniform finger pressure, ensuring complete seating. Excess cement was removed after initial settingand all specimens were allowed to set under standardized conditions before further testing

Fracture Resistance Testing

Each specimen was mounted in a universal testing machine. A compressive load was applied along the long axis of the tooth at a constant crosshead speed until fracture occurred. The maximum load at fracture was recorded in Newtons (N).

Statistical Analysis

The obtained data were analyzed using SPSS software (IBM version 25).

- One-way ANOVA was used to compare mean fracture resistance values
- Tukey post hoc test was used for intergroup comparison
- Significance level was set at $p < 0.05$

Results :

Table 1: Table showing mean and standard deviation obtained of various groups of shear bond strength using One way Descriptive statistics

Groups	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
				Lower Bound	Upper Bound
Normal Impression Scan	553.05	10.77	3.406	545.3445	560.7555
Nomal CAD CAM	951.45	11.18	3.535	943.4520	959.4480
Buccal Extension Impression Scan	687.92	9.93	3.141	680.8143	695.0257
Buccal Extension CAD CAM	1009.50	9.48	2.998	1002.7373	1016.3027

The mean and standard deviation of fracture resistance values for all the groups are presented in Table 1. The highest mean fracture resistance was observed in the Buccal Extension CAD/CAM group (1009.50 ± 9.48 N), followed by the Normal CAD/CAM group (951.45 ± 11.18 N), the Buccal Extension Impression group (687.92 ± 9.93 N), and the least was observed in the Normal Impression group (553.05 ± 10.77 N).

Table 2: Table showing One Way ANOVA to assess significant difference between the groups

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1403810.209	3	467936.736	4357.018	.000
Within Groups	3866.342	36	107.398		
Total	1407676.551	39			

The comparison of mean fracture resistance among the groups using one-way ANOVA (Table 2) revealed a highly statistically significant difference ($F = 4357.018$, $p = 0.000$), indicating that both cavity design and fabrication technique had a significant influence on fracture resistance.

Table 3: Table showing Post Hoc Tukey for multiple comparison between the groups

(I) groups	(J) groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Normal Impression Scan	Nomal CAD CAM	-398.40*	4.634	.000	-410.88	-385.91
	Buccal Extension Impression Scan	-134.87*	4.634	.000	-147.35	-122.38
	Buccal Extension CAD CAM	-456.47*	4.634	.000	-468.95	-443.98
Normal CAD CAM	Buccal Extension Impression Scan	263.53*	4.634	.000	251.04	276.01
	Buccal Extension CAD CAM	-58.07*	4.634	.000	-70.55	-45.58
Buccal Extension Impression Scan	Buccal Extension CAD CAM	-321.60*	4.634	.000	-334.08	-309.11

Further intergroup comparison using Tukey post hoc test (Table 3) demonstrated statistically significant differences between all groups ($p < 0.05$). The maximum mean difference was observed between the Normal Impression and Buccal Extension CAD/CAM groups (456.47 N), whereas the least difference was observed between the Normal CAD/CAM and Buccal Extension CAD/CAM groups (58.07 N).

Overall, the results indicate that the Buccal Extension CAD/CAM group exhibited superior fracture resistance, followed by the Normal CAD/CAM group, suggesting that both cavity modification and CAD/CAM fabrication significantly enhance the biomechanical performance of PFM endocrowns.

Discussion:

Fracture resistance of endodontically treated teeth is a critical factor influencing the longevity of restorative procedures. These teeth are structurally compromised due to the loss of marginal ridges, pericervical dentinand overall tooth structure, which significantly reduces their ability to withstand occlusal forces (1,2).

Endocrowns have emerged as a conservative alternative to conventional post and core restorations. They utilize the pulp chamber for retention and adhesive principles, thereby preserving maximum tooth structure. Previous studies have demonstrated that endocrowns provide improved stress distribution within the tooth-restoration complex, reducing stress concentration and minimizing the risk of catastrophic failure (3,4).

The fracture resistance of endocrowns is influenced by several factors, including cavity design, restorative material and fabrication technique. Among these, cavity design plays a significant role in stress distribution. Modified cavity designs, such as buccal extensions, increase the bonding surface area and improve load distribution, thereby enhancing fracture resistance (8).

In the present study, the Buccal Extension groups demonstrated higher fracture resistance compared to the conventional groups. This can be attributed to improved stress dissipation along the axial walls and increased retention. Similar findings have been reported in previous studies evaluating the effect of preparation design on endocrown performance (8).

Fabrication technique is another important factor influencing fracture resistance. CAD/CAM fabricated restorations have been shown to possess superior marginal adaptation, reduced internal defects, and improved structural homogeneity compared to conventionally fabricated restorations, as described by Mörmann(9). In addition, recent studies by Gaafar et al. (10) have also reported improved fracture resistance with CAD/CAM endocrowns. In the present study, CAD/CAM groups exhibited significantly higher fracture resistance, which is in agreement with findings reported by El Ghoul et al. (5).

The most significant finding of this study was that the Buccal Extension CAD/CAM group showed the highest fracture resistance, indicating a combined effect of cavity design and fabrication technique. This suggests that optimal biomechanical performance can be achieved by simultaneously improving both preparation design and fabrication accuracy which is consistent with findings by Dejak and Młotkowski (11).Bindl et al. (12) also demonstrated favourable survival rates of CAD/CAM restorations even with reduced retention designs. These findings further support the clinical reliability of CAD/CAM-fabricated endocrowns.

These findings are in agreement with previous studies, where Biacchi and Basting (13) reported higher fracture resistance of endocrowns compared to conventional post-retained restorations.

The present study specifically evaluated PFM endocrowns, which differ from all-ceramic endocrowns in their mechanical behavior. The presence of a metal substructure provides increased resistance to crack propagation and enhances the ability of the restoration to withstand higher occlusal loads. This makes PFM restorations particularly suitable for posterior teeth subjected to heavy masticatory forces (7).

In the present study, glass ionomer cement (GIC) was used for cementation due to the presence of a metal intaglio surface in PFM restorations, which limits the effectiveness of adhesive bonding. GIC provides chemical adhesion to tooth structure and is commonly used for metal-based restorations; however, it exhibits lower bond strength compared to resin-based cements (14).

Although materials such as lithium disilicate and zirconia have demonstrated high fracture strength, they are associated with brittleness and higher cost. In contrast, PFM restorations provide a combination of strength, durability, and cost-effectiveness, making them a reliable option for posterior restorations (7).

The findings of the present study showed that all groups exhibited fracture resistance values higher than normal masticatory forces, indicating their clinical applicability. However, the Buccal Extension CAD/CAM group demonstrated superior performance compared to other groups.

This study has certain limitations, as it was conducted under in vitro conditions and does not completely simulate the oral environment. Factors such as thermocycling, fatigue loading, and intraoral conditions were not considered. Further clinical studies are required to validate these findings.

Conclusion:

Within the limitations of this in vitro study, it can be concluded that cavity design and fabrication technique significantly influence the fracture resistance of PFM endocrowns. Buccal extension design and CAD/CAM fabrication demonstrated superior performance, with their combination showing the highest fracture resistance.

PFM endocrowns exhibited adequate strength for posterior applications; however, further clinical studies are required to validate these findings.

References:

1. Dietschi D, Duc O, Krejci I, Sadan A. Biomechanical considerations for the restoration of endodontically treated teeth: a systematic review of the literature. *Quintessence Int*. 2008;39(9):733–743. Available from: https://pubmed.ncbi.nlm.nih.gov/18833858/
2. Reeh ES, Messer HH, Douglas WH. Reduction in tooth stiffness as a result of endodontic and restorative procedures. *J Endod*. 1989;15(11):512–516.Available from: https://doi.org/10.1016/S0099-2399(89)80191-8
3. Rocca GT, Krejci I. Bonded indirect restorations for posterior teeth: From cavity preparation to provisionalization. *Int J Esthet Dent*. 2013;8(1):46–58. Available from: https://pubmed.ncbi.nlm.nih.gov/23495507/
4. Bindl A, Mörmann WH. Clinical evaluation of adhesively placed CEREC endocrowns after 2 years. *J Prosthet Dent*. 1999;82(5):557–562. Available from: https://doi.org/10.1016/S0022-3913(99)70098-2
5. El Ghoul W, Özcan M, Silwadi M, Salameh Z. Fracture resistance and failure modes of endocrowns manufactured with different CAD/CAM materials. *J EsthetRestor Dent*. 2019;31(4):378–387. Available from: https://doi.org/10.1111/jerd.12486
6. Sedrez-Porto JA, da Rosa WL, da Silva AF, Münchow EA, Pereira-Cenci T. Endocrown restorations: A systematic review and meta-analysis. *J Dent*. 2016;52:8–14. Available from: https://doi.org/10.1016/j.jdent.2016.07.003
7. Sorensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. *J Prosthet Dent.* 1984;51(6):780–784.Available from: https://doi.org/10.1016/0022-3913(84)90376-5
8. Dartora NR, de Conto Ferreira MB, Moris IC, et al. Effect of intracoronal depth and restorative material on fracture strength of endocrowns. *J Prosthet Dent.* 2018;120(5):770–777.Available from: https://doi.org/10.1016/j.prosdent.2017.12.020
9. Mörmann WH. The evolution of the CEREC system. *J Am Dent Assoc*. 2006;137 Suppl:7S–13S. Available from: https://doi.org/10.14219/jada.archive.2006.0398
10. Chang CY, Kuo JS, Lin YS, Chang YH. Fracture resistance and failure modes of CEREC endocrowns and conventional post and core-supported crowns. *J Dent Sci*. 2009;4(3):110–117.Available from: https://doi.org/10.1016/S1991-7902(09)60020-8
11. Dejak B, Młotkowski A. Three-dimensional finite element analysis of molars restored with endocrowns and posts during masticatory simulation. *Dent Mater.* 2013;29(12):e309–e317.Available from: https://doi.org/10.1016/j.dental.2013.09.010
12. Bindl A, Richter B, Mörmann WH. Survival of ceramic computer-aided design/manufacturing crowns bonded to preparations with reduced macroretention geometry. *Int J Prosthodont*. 2005;18(3):219–224. Available from: https://pubmed.ncbi.nlm.nih.gov/15944963/
13. Biacchi GR, Basting RT. Comparison of fracture strength of endocrowns and glass fiber post-retained conventional crowns. *Oper Dent*. 2012;37(2):130–136. Available from: https://doi.org/10.2341/11-140-L
14. Mount GJ. Clinical performance of glass-ionomer cements. *Biomaterials.* 1998;19(6):573–579.Available from: https://doi.org/10.1016/S0142-9612(97)00119