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Research Article

Effect of Endodontic Access Preparation on the Retention of Zirconia Crowns with Temporary or Permanent Access Hole Restorations: An In Vitro Study

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Abstract

Objectives: To evaluate the effect endodontic access preparation had on the retention of anterior zirconia crowns after restoring the access hole with temporary versus permanent restorative materials.

Methods: 30 anterior zirconia crowns were milled from 5Y-TZP zirconia and bonded to a 3D printed die with resin cement. Crowns were randomly divided into three groups including negative control (NC, n=10) with no endodontic access preparation; positive control (PC, N=10) received endodontic access preparation and was restored with a temporary restorative material (Cavit); composite restoration (CR, N=10) received an endodontic access preparation and then the access hole was restored with composite resin.

Results: Considering the retention of crowns in NC group, PC group lost approximately 50% of its retention while the CR group had approximately 150% increase in the retention. The difference between the three groups was statistically significant ($P<0.05$).

Conclusion: Restoring the endodontic access hole of a central incisor zirconia crown with composite resin improves the retention of the crown.

Keywords: Endodontic Access, Composite Restoration, Anterior Crown, Zirconia, Crown Retention

Introduction

It has been proven that teeth restored with full coverage crowns have a 95 percent retention rate of at least 5 years [1]. Vital teeth or previously endodontically treated teeth with crowns may develop pulpal or periapical disease [2]. When providing endodontic care on a tooth with a fabricated crown, the crown either has to be removed or the root canal procedure has to be completed through the crown. It has been noted that crowns may become displaced during endodontic access preparation in a clinical situation [3]. Endodontic access preparation through zirconia crowns is becoming more relevant in modern dentistry with an increase in the use of zirconia crowns [4]. A crown that is functional, esthetic, and with intact margins often does not have to be replaced when endodontic treatment is deemed necessary for the tooth especially when the sufficient thickness of restorative material is present [5, 6, 7].

Over the last few decades, metal-ceramic crowns have become the restoration of choice due to their esthetic quality and high success rate [4]. Zirconia crowns have shown excellent hardness, marginal fit, and bond strength. [8, 9, 10]. Zirconia (zirconium dioxide, ZrO2) has some features (low corrosion potential, low thermal conductivity, good biologic compatibility, and good radiographic contrast) that make it the material of choice where high functional and esthetic issues are concerned [11]. There are many materials used to restore access openings in crowns accessed for endodontic therapy. Malvey, et al concluded that the displacement force of high palladium/low gold crowns was significantly lower in accessed crowns [5]. From that study, restoration with either glass ionomer or amalgam showed an increase of the original value for retention. McMullen, et al [12] showed a decrease in crown retention of PFM crowns when an endodontic access is prepared. That study concluded, however, that the original retention was not only restored but surpassed when the preparation was restored with amalgam.

Crown retention is an important factor of fixed prosthetics with several factors affecting retention such as taper, surface area, length and height of preparation, diameter of tooth, texture of the tooth, and accessory means. The retention of a crown preparation combined with the effect of the luting agent determines the quantity of force needed to unseat a restoration [13]. Endodontic access preparation of the maxillary central incisor requires entrance through the palatal surface [14], and the palatal wall of the maxillary central incisor crown preparation is considered an axial wall and subsequently influences retention [15]. Therefore, the endodontic access preparation potentially removes a key factor in the crown's retentive structure.

Current studies discussing crown retention after endodontic access preparation focus on porcelain fused to metal crowns that are restored with materials such as composite resin and amalgam [12,13,16]. These studies show that the PFM crown retention is reduced after endodontic access preparation [13]. However, they then show that subsequent restoration with amalgam or composite may increase the original retention of the crown [12, 16]. Currently there are no studies describing the effect endodontic access preparation has on anterior zirconia crown retention nor the best method of restoring these openings. The aim of the present study was to evaluate the effect endodontic access preparation has on the retention of anterior zirconia crowns when the access hole is restored with different restorative materials. The first null hypothesis was that the endodontic access hole does not influence the retention of anterior zirconia crowns. The second null hypothesis was that the type of restorative material used to close the endodontic access hole does not influence the retention of the zirconia crowns.

Methods

In the present study, anterior tooth dies were printed out of 3D printable resin (Sprintray Ceramic Crown, Sprintray, CA) in a DLP-printer (Pro2, Sprintray) from a master model of a maxillary central incisor, which had uniform circumferential internally rounded shoulder marginal preparation of 1.0 mm depth and total occlusal convergence of 12 degrees with rounded edges. After fabrication of the tooth dies, crowns with axial wall thicknesses of 1 mm and incisal thickness of 2 mm were designed in a CAD software (inLab, Dentsply Sirona, NC) with two wings on the proximal surface (Fig 1). A central incisor crown was designed in a CAD software with two wings for crown removal with an Instron machine. Crowns were then dry milled using a translucent zirconia (VITA YZ XT, VITA North America, CA) containing 5 mol% yttria (5Y). Crowns were sintered in the furnace (inLab Profire, Dentsply Sirona) using the manufacturer's recommended sintering cycle. Thirty total crowns (Fig 2) were fabricated (n=10 per group).

Figure 1. *Design of the anterior zirconia crown with two wings to aid in the crown removal by the Instron Machine in a CAD software*

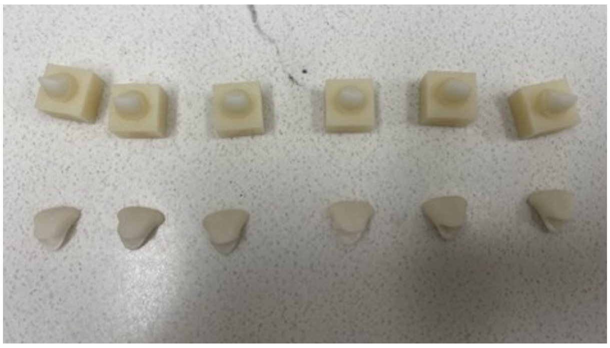

Figure 2. *Sintered zirconia crowns and 3D printed dies.*

Sintered crowns were air-abraded with alumina particles (50 µm, Kramer Industries, NJ) at 1 bars pressure for 10 seconds at a 10 mm distance. The remaining alumina particles were removed from the intaglio by placing the crowns in an ultrasonic bath with deionized water for 10 minutes. Crowns were bonded on the 3D printed dies using a self-adhesive resin cement (Panavia SA Universal, Kuraray, Japan). Next, crowns were placed under 1000 g of weight (Fig 3) for 6 minutes and after removing the excess cement, light cured for 20 seconds from the buccal and lingual. The specimens were kept in an incubator at 37°C for 24 hours. Then the crowns were randomly divided into three groups:

Negative Control (NC, n=10): no access hole was created, and the crowns were removed by the universal testing machine (Instron 5566, Norwood, MA) utilizing a custom metal jig (Fig 4) fitting to the proximal surfaces of the crowns with cross -head speed of 0.5 mm/min until displacement (Fig 5). The highest force of displacement was then recorded in Newtons.

Figure 3. *Cemented crowns under constant load of 1000 gram.*

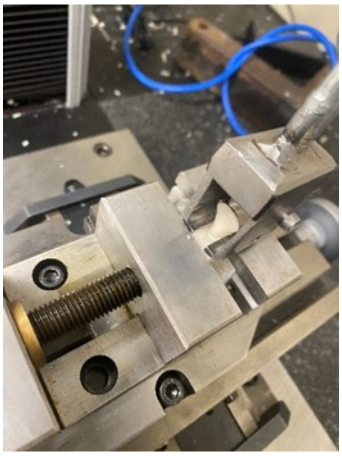

Figure 4. *Custom made jig holding on the wings to displace the crowns.*

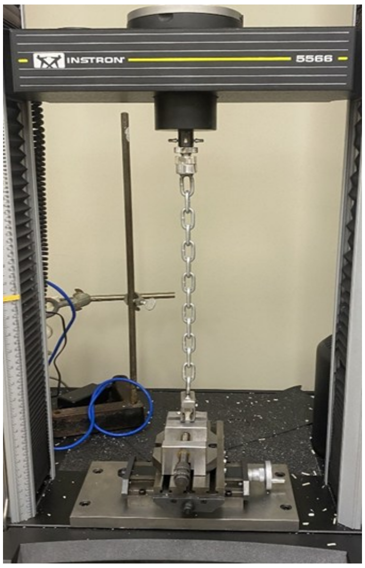

Figure 5. *Mounted specimen in the Instron universal testing machine.*

Positive Control (PC, n=10): an endodontic access preparation was created using a predesigned pattern to standardize the access hole in all the crowns following the ADEX dental exam guidelines for an anterior endodontic access preparation. The depth of the access into the die was to the level of the cemento-enamel junction (CEJ). After the endodontic access preparation, the access hole was restored with a cotton pellet and temporary restorative material (Cavit). Crowns were displaced similar to the NC group.

Composite Restoration (CR, n=10): an endodontic access preparation was created using a predesigned pattern to standardize the access hole in all the crowns. After the endodontic access preparation, a universal adhesive (Single Bond Universal, Solventum, MN) was applied and light cured for 20 seconds, then the access hole was restored with a permanent restorative material (Filtek Supreme Ultra, Solventum). Crowns were next displaced similar to the NC group.

The measurements were tested for normality using Kolmogrov-Smirnov test. Descriptive statistics including mean and standard deviation were used to present the retention force of the crowns in each group. In order to examine the effects of endodontic access preparation and restorative material type on the retention force, a one-way analysis of variance (ANOVA) test was performed. In addition, pairwise comparisons were performed using a Tukey post hoc test. Statistical analysis was performed in SPSS version 29.0 software (IBM SPSS Statistics, Armonk, NY) and all tests were two-sided with the α set at 0.05.

Results

The retention values of the tested groups is summarized in table 1. According to the one-way ANOVA test, a statistically significant difference in the retention values was found ($P<0.001$). According to the post-hoc Tukey test, the retention value of composite group was significantly higher than the other two groups ($P<0.001$). Moreover, the retention value of the control group was significantly higher than the Cavit group ($P=0.004$).

Table 1. Retention values (N) of different tested groups.

Group	Mean	Standard Deviation
Control	98.86	22.84
Cavit	49.98	27.19
Composite	249.55	39.15

Discussion

The aim of the present study was to evaluate the effect endodontic access preparation and the type of restoration in the access hole have on the retention of anterior zirconia crowns. The first null hypothesis was that the endodontic access hole does not influence the retention of anterior zirconia crowns. This hypothesis was rejected as the retention force of the PC group reduced significantly when compared with NC group. Similar to the present findings, Brezinsky et al [16] showed molar PFM crowns had between 82% and 91% of their original retention after access preparation and McMullen et al [12] showed a significant decrease in anterior PFM crown retention after access preparation too.

The second null hypothesis was that the type of restorative material used to restore the endodontic access hole does not influence the retention of the zirconia crowns. This hypothesis was also rejected as the retention of the crowns restored with composite resin (CR group) was significantly higher than the crowns restored with a temporary material (PC group). This could be attributed to the fact that universal adhesive systems enhance composite bonding to zirconia [17]. In an in vivo setting, the added bonded surface area of the composite to the tooth structure would also lead to increased retention. These results also align with the results of Brezinsky et al [16] that proved that a molar PFM crown that had been accessed and restored with composite had 195% of the original crowns retention.

Selecting the correct bur when creating the endodontic access hole is crucial considering the cutting efficiency and the degree of damage the bur can create around the access hole [7]. Microcracks, minor chipping, or catastrophic fractures are potential complications we may face while creating an endodontic access hole[18,19]. A 126-μm grit size diamond bur is designed to efficiently remove ceramics with acceptable efficiency and minimal dulling. Qeblawi et al. [20] reported that a 126-μm grit size bur, rather than a diamond bur with larger grit size, minimizes the damage to lithium disilicate crowns and maintains the integrity of the tooth-cement interface. Similar to the present study, Nejat et al. [7] used diamond burs with a 126-μm grit size to create endodontic access holes in 5Y zirconia. In addition, in the present study, a high speed electric hand piece with copious water spray was used to create the access preparation. Water spray acts as a coolant and reduces the heat accumulated in the zirconia at the point of bur contact. It also removes the cutting debris and acts as a lubricant which helps maintain the cutting efficiency of the bur [7, 18].

The anterior endodontic access preparation was completed on the palatal surface utilizing a high-speed rotary cutting instrument under water spray according to ADEX dental exam guide lines for anterior endodontic access preparation. The guidelines state that the access preparation must remain 2 mm from the incisal edge, 1 mm from both mesial and distal marginal ridges, and 3 mm from the CEJ. The access must also be placed on the palatal surface directly over the pulp chamber which allows for the pulp horns to be fully removed and complete debridement of the pulp chamber by affording straight-line access to the root canal system. We also placed a putty matrix on the palatal surface of the crowns to stay within the acceptable bounds. The depth of preparation was made to 10 mm which was the length of the crown.

One of the limitations of the present study was that the dies in the present study were not natural teeth and lack dentinal tubes and other factors that could affect the bond of crowns to the die. However, the 3D printed anterior teeth dies allowed us to standardize our crown design so that differences in preparation including convergence degree, axial wall reduction, or surface area of the die did not affect our crown retention results [21]. The other limitation of the present study was that the crowns were not aged after bonding and did not go through the fatigue cycles. This could affect the results because the retention of the crowns could be affected by the fatigue process.

Conclusion

In conclusion, endodontic access preparation through a central incisor 5Y zirconia crown decreased the retention of the crown by approximately 50% compared to a control crown with no access preparation. The results of the present study indicated that restoring the endodontic access preparation with composite resin not only restores the retention of a 5Y zirconia crown with endodontic access, but can also increases the original retention of the crown by approximately 150%.

Conflicts of Interest

The authors declare no conflicts of interest.

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References

1. Bader JD, Shugars DA. Summary review of the survival of single crowns. Gen Dent 2009;57: 74–81.
2. Goodacre CJ, Spolnik KJ. The prosthodontic management of endodontically treated teeth: a literature review—part I: success and failure data, treatment concepts. J Prosthod 1994;3: 243–50.
3. Bergenholtz G. Endodontic complications following periodontal and prosthetic treatment of patients with advanced periodontal disease. J Periodontal 1984;55:63-8.
4. Örtorp A., Kihl M. L., Carlsson G. E. A 3-year retrospective and clinical follow-up study of zirconia single crowns performed in a private practice. *Journal of Dentistry.* 2009;37(9):731–736. doi: 10.1016/j.jdent.2009.06.002.
5. Mulvay PG, Abbott PV. The effect of endodontic access cavity preparation and subsequent restorative procedures on molar crown retention. Aust Dent J 1996;41:134–9.
6. Crumpton BJ, Goodell GG, McClanahan SB. Effects on smear layer and debris removal with varying volumes of 17% REDTA after rotary instrumentation. J Endod 2005;31:536–8.
7. Nejat AH, Dupree P, Kee E, et al. Effect of Endodontic Access Preparation on Fracture Load of Translucent versus Conventional Zirconia Crowns with Varying Occlusal Thicknesses. *J Prosthodont*. 2021;30(8):706-710.
8. Colombo M., Poggio C., Lasagna A., Chiesa M., Scribante A. Vickers micro-hardness of new restorative CAD/CAM dental materials: evaluation and comparison after exposure to acidic drink. *Materials.* 2019;12(8):p. 1246. doi: 10.3390/ma12081246.

9. Saab R. C., Da Cunha L. F., Gonzaga C. C., Mushashe A. M., Correr G. M. Micro-CT analysis of Y-TZP copings made by different CAD/CAM Systems: marginal and internal fit. *International Journal of Dentistry.* 2018;2018 doi: 10.1155/2018/5189767.5189767

10. Lee Y., Chul Oh K., Kim N.-H., Moon H.-S. Evaluation of zirconia surfaces after strong-acid etching and its effects on the shear bond strength of dental resin cement. *International Journal of Dentistry.* 2019;2019 doi: 10.1155/2019/3564275.3564275

11. Miyazaki T., Nakamura T., Matsumura H., Ban S., Kobayashi T. Current status of zirconia restoration. *Journal of Prosthetic Dentistry.* 2013;57(4):236–261. doi: 10.1016/j.jpor.2013.09.001.

12. McMullen AF 3rd, Himel VT, Sarkar NK. An in vitro study of the effect endodontic access preparation and amalgam restoration have upon incisor crown retention. J Endod 1990;16: 269–72

13. McMullen AF 3rd, Himel VT, Sarkar NK. An in vitro study of the effect endodontic access preparation has upon the retention of porcelain fused to metal crowns of maxillary central incisors. J Endod 1989;15:154–6.

14. Ingle Jl. Endodontics. 3rd ed. Philadelphia: Lea & Febinger, 1965:118.

15. Thayer KE. Fixed prosthodontics. Chicago: Yearbook Medical Publishers, 19

16. Brezinsky S, Bowles W, McClanahan S, Fok A, Ordinola-Zapata R. In Vitro Comparison of Porcelain Fused to Metal Crown Retention after Endodontic Access and Subsequent Restoration: Composite, Amalgam, Amalgam with Composite Veneer, and Fiber Post with Composite. J Endod. 2020 Nov;46(11):1766-1770. doi: 10.1016/j.joen.2020.08.009. Epub 2020 Aug 17. PMID: 32818565.

17. Dos Santos RA, de Lima EA, Mendonça LS, et al. Can universal adhesive systems bond to zirconia?. *J Esthet Restor Dent*. 2019;31(6):589-594. doi:10.1111/jerd.12521

18. Gorman CM, Ray NJ, Burke FM: The effect of endodontic access on all-ceramic crowns: A systematic review of in vitro studies. J Dent 2016;53:22-29.

19. Bompolaki D, Kontogiorgos E, Wilson JB, et al: Fracture resistance of lithium disilicate restorations after endodontic access preparation: An in vitro study. J Prosthet Dent 2015;114:580-6.

20. Qeblawi D, Hill T, Chlosta K: The effect of endodontic access preparation on the failure load of lithium disilicate glass-ceramic restorations. J Prosthet Dent 2011;106:328-36.

21. Sayed Ahmed A, Lawson NC, Fu CC, Bora PV, Kee E, Nejat AH. The Effect of Die Material on the Crown Fracture Strength of Zirconia Crowns. *Materials (Basel)*. 2024;17(5):1096. Published 2024 Feb 28. doi:10.3390/ma17051096