AJDS ALAZHAR
Al-Azhar Journal of Dental Science
Vol. 23- No. 3- 235:240- July 2020
Record 1110-2624 | the ISSN Portal
portal.issn.org

EFFECT OF CEMENT GAP ON THE RETENTION OF ZIRCONIA CROWN

Ahmed Yousef Elbieh[*], Khaled Mohamed Haggag[**], Hesham Ibrahim Othman[**]

ABSTRACT

Objective: To evaluate the effect of different cement gap on retention of zirconia crowns cemented with resin cement. **Materials and methods**: Thirty natural human molar teeth were collected and mounted in an acrylic mold. Teeth were prepared through CNC, and then zirconia crowns fabricated by CAD/CAM. Samples were divided into 3 subgroups according to the cement gap (CG) (n=10): 25µm (CG25), 50µm (CG50), 100µm (CG100). Zirconia crowns cemented with Breeze Self-Adhesive Resin Cement. Samples were thermocycled for 5000 cycles between two water baths at 5˚C and 55˚C with a dwell time of 20 seconds and 10 seconds of transfer time. Samples were subjected to tensile test, dislodgment force recorded in MPa. **Results:** No significant difference was found between mean pull-out bond strength at different cement gaps. **Conclusion:** The 25 µm cement gap gave the best retention for zirconia restorations.

Keywords: Cement gap, Retention, Resin cement, Zirconia

INTRODUCTION

Retention and accurate fit of extra coronal restorations are of prime concern for both the dentist as well as the patient. Displacement of the fixed dental prosthesis is best prevented by proper tooth preparation, by closely adapted internal surface and margin. Cementation variables such as type of cement, physical and mechanical properties of the luting agent, placement techniques, seating force, and environmental conditions also play essential roles on the long-term success of restorations[1].

Dental luting agents serve as a link between the prepared supporting tooth and FDPs. During the last decades, dental luting cements have evolved with a rapid rate, among these newly introduced luting cements is the bioactive luting cement. These cements fall under a well-known and long-standing group of dental and medical materials: the chemically bonded ceramic (CBC) cements. These cements are water-based and hence also often termed “hydraulic” cements. This group of dental materials is set by an acid-base reaction that is the basis of CBC cements in dentistry. This trend is further defined by three significant functional aspects: (1) adhesion to the tooth structure, (2) continuous release of measurable levels of fluoride, and (3) an increasing trend toward the development, use, or incorporation resin methacrylate chemistry in dental restorative materials and cements[2,3].

Aim of this study was to evaluate the effect of cement gap on the retention of zirconia crowns. The hypothesis was that the smallest cement gap would give the highest retention.

MATERIAL AND METHOD

A total of 30 extracted natural molar teeth were used in the study. Teeth were checked under a magnifying glass to be free from caries, debris, or crack. The teeth were randomly assigned in three groups (n=10) according to the used cement gap (CG) setting in the CAD system; 25µm (CG25), 50µm (CG50), and 100µm (CG100).

[*] PhD candidate, Crown and Bridge Department, Faculty of Dental Medicine (Boys- Cairo) Al-Azhar University
[**] Professor, Crown and Bridge Department, Faculty of Dental Medicine (Boys- Cairo) Al-Azhar University

Teeth were embedded vertically into acrylic resin blocks. Preparation was done so that the occlusal surface was flat, with a 1mm round shoulder finish line, 4mm height, and a total convergence angle of 20°.

An optical impression of each abutment was made with the Medit i500 (Medit, Seoul, Korea) intraoral camera. Zirconia coping was designed in wax with an enlarged projection on the occlusal portion of zirconia coping designed to be 5-mm thick. A 2-mm hole added manually on the occlusal portion of the design to provide a way of pulling the coping during retention testing.

Using exocad software (Exocad GmbH, Darmstadt, Germany), scans were modified to allow 25-µm, 50 µm, and100 µm relief (cement gap). Roland dwx 50 (Roland DG Corp) was used to mill the coping from DD Bio Z – High Strength (HS) (Dental Direkt, Spenge, Germany), burs were changed after five millings, to control any variability in bur wear. Zirconia copings were sintered according to the manufacturer's instructions.

Sandblasting was carried out to zirconia copings using 50 µm Aluminum oxide particles (Al_2O_3) applied perpendicular to the surface, using an airborne particle-abrasive device. The specimens were held at a distance of 10 mm between the surface of the sample and the blasting tip. Air-abrasion was performed for 15 seconds, with 3 bar pressure. Samples were cleaned by ultrasonic cleaner for one minute.

The scanned abutments .obj files were used to calculate the surface area (mm^2) of the prepared tooth using the software Meshlab 2016.

Breeze self-adhesive cement (auto-mix) was used according to manufacturer's instruction, and a static load of 50 N placed over the samples for 5 minutes using a specially designed loading device, excess cement was removed after initial setting. After complete setting and polymerization of the luting cements, samples were placed in distilled water for 24 hours to allow the relief of internal stresses of the cement.

All samples undergone thermocycling for 5000 cycles between two water baths at 5°C and 55°C with a dwell time of 20 seconds in each bath and 10 seconds of transfer time.

Retention was measured by Universal Testing Machine (Model 3345; Instron Industrial Products, Norwood, USA) with a load cell of 5 kN. Data was recorded using computer software (Bluehill Lite; Instron Instruments). The crown was suspended from the upper movable compartment of the testing machine by an orthodontic wire loop (0.7 mm) through the hole at occlusal projections made during milling, while the epoxy base of the sample secured at the bottom of the testing machine. The device was subjected to a slowly increasing vertical load (1mm/min) until total dislodgment of the crown. The force required to dislodgment was recorded in Newton (N).The retention force was calculated in MPa by the formula:

$$\text{Retention (MPa)} = \frac{\text{Debonding Force (N)}}{\text{Total Bonding Surface Area of Preparation (mm}^2\text{)}}$$

RESULTS

There was no statistically significant difference between mean pull-out bond strength at difference cement gaps (p-value = 0.285, Effect size = 0.069), figure (1) and table (1).

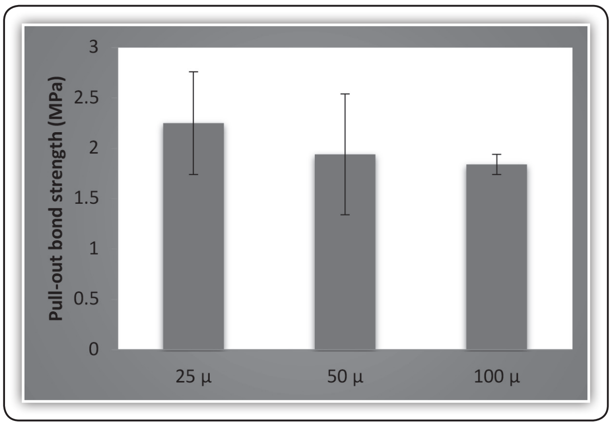

FIG (1) Bar chart representing mean and standard deviation values for pull-out bond strength with different interactions of variables

TABLE (1) The mean, standard deviation (SD) values and results of two-way ANOVA test for comparison between pull-out bond strength values with different interactions of variables

Cement gap	Resin cement		p-value	Effect size (Partial eta squared)
	Mean	SD		
25 µ	2.25	0.51	0.256	0.037
50 µ	1.94	0.6	0.014*	0.160
100 µ	1.84	0.1	0.484	0.014
P-value	0.285			
Effect size (Partial eta squared)	0.069			

**: Significant at $p \leq 0.05$, Different superscripts in the same column indicate statistically significant differences between cement gaps*

DISCUSSION

In the present study, the influence of different cement gaps on the retention of zirconia crowns cemented with self-adhesive resin cement was studied.

Dental luting cements play a vital role in the success of indirect restorations. The primary function of the luting cement is to fill the space between the prepared tooth and indirect restoration, in addition to mechanically or chemically bonding the restoration to the preparation to prevent dislodgement during the function[4–6].

Resin cements have gained popularity in the dental market during recent years due to high compressive and tensile strengths, low solubility, and favorable esthetic qualities. Besides, in vitro and in vivo studies suggest that resin bonding helps diffuse stress and limit crack propagation on the internal aspect of porcelain restorations[7]. However, they are expensive and have the disadvantages of being technique sensitive, easily contaminated during multiple-step application procedures, and difficult and time-consuming during clean-up[8].

They can be categorized based on the bonding process as (a) total etch adhesive resin cements (b) self-etch adhesive resin cements and (c) self-adhesive resin cements.

It is well recognized that any new luting cement (or, for that matter, any new dental material) should be characterized by several laboratory physical and mechanical tests to elucidate that material's physical properties. Therefore, the objective of this experimental study was to test the effect of the cement gap of self-adhesive resin cement regarding retention, according to the International Organization for Standardization (ISO) 11405:2015 (testing of adhesion to tooth structure). Breeze self-adhesive dual-cure resin cement was subjected to retention testing.

Crown retention is known to be influenced by a number of different parameters: the abutment size and surface roughness, [9,10] the total convergence angle of the walls of the abutment, and the used cements[11].

However, because retention failures are still a major complication in fixed prosthodontics[12], there is a need to study the contributing factors for further development of new and better luting cements.

The most common laboratory tests which assess the adhesive properties of a luting agent are shear, tensile and microtensile or push-out bond strength tests[13]. The advantages of bond strength tests are reproducibility and ease of conducting the test.

The drawback is that the bond strength testing does not reflect the clinical situation where the thixotropic cement applied under pressure during crown insertion exhibits flow and lower viscosity permitting it to bond differently than a passive bonding test to a flat prepared tooth. Therefore, crown tensile testing procedures were developed to stimulate clinical procedures more closely(13).

Many parameters influence crown retention. These include crown convergence angle, cyclic loading, the surface roughness of the abutment, and the intaglio surface of the restoration as well as the cement(9,10).

Zidan and Ferguson compared the retention strength achieved with three different tapers of 6-degrees, 12-degrees, and 24-degrees. The concluded that the retentive values of the adhesive resins at 24-degree taper were 20% higher than the retentive values of the conventional cements at 6-degree taper(14).

The influence of the type of cement is controversial with several studies, showing that resin cement has higher retention strength than conventional cements(15–17). However, Rosario et al. found similar crown retention strength of total-etch resin cement, self-adhesive resin cement, and a RMGI cement(18).

Retention of the single-unit crowns is influenced by the taper angle-–the angle of convergence between the opposing axial walls. The retention of bonded crowns has been shown to depend on the taper angle: the lower the taper angle, the higher the retention(11,18–20). The maximum retention is obtained between 6° and 12° taper(14). In practice, ideal axial wall convergence may not be routinely obtained. Studies have reported mean taper angles ranging from 3° to 26°(21).

Jing et al.(22) concluded that zirconia crowns are related to occluso-cervical heights, so 4mm abutment height was used in the current study so that the effect of cement gap to the retention of crowns may be better evaluated.

Samples were stored in a 37 °C water bath for 24 hours before the bonding procedure was done to represent the exact oral temperature, which may increase the polymerization of the resin cements.

To simulate oral environment conditions, samples were thermocycled. Thermocycling mirrors the temperature variance occurring in the oral cavity(23). It was reported by Gale et al. that if one year of clinical service is the aim, then 10,000 cycles are required(24). In our study samples were thermocycled for 5000 cycles as recommended by Iso test for testing adhesion with tooth structure(25).

The use of a different ceramic, the treatment of the ceramic crown intaglio surface, the aging conditions, the degree of convergence, the axial wall length, the surface area measurement, and the type of cement, were all different from previous studies. Furthermore, the physical properties of different resin cement may influence the retentive qualities.

Our pull-out test results showed standard deviations lower than those in previously published studies. As mentioned previously, this is presumably because of strictly standardized protocol at every stage.

Regarding the cement gap, 50 µm group scored the highest pull-out bond strength [2.26±0.61], followed by 25 µm group scored [2.1±0.44], and finally, 100 µm group scored [1.94±0.5], this can be explained that 50 µm cement gap form the best fit for the zirconia coping to the abutment as it is not too tight nor too wide, this result is in agreement with Gultekin et al. (37), as they found that increasing the cement gap from 20 to 40 µm led to significantly greater retention. For the 100 µm gap, the cement thickness will increase, leading to decrease retention.

Limitations:

1. Extracted human natural teeth were used in the current study, whereas natural teeth should be used to match the clinical situations. However, the use of standard dies may have an advantage in that equalizing the surface area.

2. The use of a pure tensile test. In a clinical situation, it is likely that other forces also contribute to crown de-cementation. However, the tensile test was adopted in our study to allow comparisons with previous studies.

CONCLUSION

The 25 µm cement gap gave the best retention for zirconia restorations.

REFERENCES

1. Haselton DR. Contemporary Fixed Prosthodontics. J Prosthodont. 2004 Aug 9;11(3):227–8.
2. Sachs C, Groesser J, Stadelmann M, Schweiger J, Erdelt K, Beuer F. Full-arch prostheses from translucent zirconia: Accuracy of fit. Dent Mater. 2014 Aug;30(8):817–23.
3. Heintze SD, Rousson V. Survival of zirconia- and metal-supported fixed dental prostheses: a systematic review. Int J Prosthodont. 2010;23(6):493–502.
4. Edelhoff D, Ozcan M. To what extent does the longevity of fixed dental prostheses depend on the function of the cement? Working Group 4 materials: cementation. Clin Oral Implants Res. 2007 Jun;18 Suppl 3:193–204.
5. Rosenstiel SF, Land MF, Crispin BJ. Dental luting agents: A review of the current literature. J Prosthet Dent. 1998 Sep;80(3):280–301.
6. Krämer N, Lohbauer U, Frankenberger R. Adhesive luting of indirect restorations. Am J Dent. 2000 Nov;13(Spec No):60D-76D.
7. Burke FJT, Fleming GJP, Nathanson D, Marquis PM. Are adhesive technologies needed to support ceramics? An assessment of the current evidence. J Adhes Dent. 2002;4(1):7–22.
8. Pace LL, Hummel SK, Marker VA, Bolouri A. Comparison of the Flexural Strength of Five Adhesive Resin Cements. J Prosthodont. 2007 Jan;16(1):18–24.
9. Stawarczyk B, Basler T, Ender A, Roos M, Özcan M, Hämmerle C. Effect of surface conditioning with airborne-particle abrasion on the tensile strength of polymeric CAD/CAM crowns luted with self-adhesive and conventional resin cements. J Prosthet Dent. 2012 Feb;107(2):94–101.
10. Cano-Batalla J, Soliva-Garriga J, Campillo-Funollet M, Munoz-Viveros CA, Giner-Tarrida L. Influence of abutment height and surface roughness on in vitro retention of three luting agents. Int J Oral Maxillofac Implants. 2012;27(1):36–41.
11. Ali AO, Kelly JR, Zandparsa R. The Influence of Different Convergence Angles and Resin Cements on the Retention of Zirconia Copings. J Prosthodont. 2012 Dec;21(8): 614–21.
12. Burke FJT, Lucarotti PSK. Re-intervention on crowns: What comes next? J Dent. 2009 Jan;37(1):25–30.
13. Heintze SD. Crown pull-off test (crown retention test) to evaluate the bonding effectiveness of luting agents. Vol. 26, Dental Materials. 2010. p. 193–206.
14. Zidan O, Ferguson GC. The retention of complete crowns prepared with three different tapers and luted with four different cements. J Prosthet Dent. 2003 Jun;89(6):565–71.
15. Mitchell C. The influence of luting cement on the probabilities of survival and modes of failure of cast full-coverage crowns. Dent Mater. 2000 May;16(3):198–206.
16. Wolfart S, Linnemann J, Kern M. Crown retention with use of different sealing systems on prepared dentine. J Oral Rehabil. 2003 Nov;30(11):1053–61.
17. Johnson GH, Hazelton LR, Bales DJ, Lepe X. The effect of a resin-based sealer on crown retention for three types of cement. J Prosthet Dent. 2004 May;91(5):428–35.
18. Gundler A, Lockowandt P, Erhardson S. Crown retention and cyclic loading (in vitro). Eur J Oral Sci. 1993 Aug;101(4):252–6.
19. Wiskott HW, Nicholls JI, Belser UC. The relationship between abutment taper and resistance of cemented crowns to dynamic loading. Int J Prosthodont. 1996;9(2):117–39.
20. Cameron SM, Morris WJ, Keesee SM, Barsky TB, Parker MH. The effect of preparation taper on the retention of cemented cast crowns under lateral fatigue loading. J Prosthet Dent. 2006 Jun;95(6):456–61.
21. Dodge WW, Weed RM, Baez RJ, Buchanan RN. The effect of convergence angle on retention and resistance form. Quintessence Int. 1985 Mar;16(3):191–4.
22. Jing L, Chen J-W, Roggenkamp C, Suprono MS. Effect of Crown Preparation Height on Retention of a Prefabricated Primary Posterior Zirconia Crown. Pediatr Dent. 2019 May 15;41(3):229–33.
23. Amaral FLB, Colucci V, Palma-Dibb RG, Corona SAM. Assessment of In Vitro Methods Used to Promote Adhesive Interface Degradation: A Critical Review. J Esthet Restor Dent. 2007 Dec;19(6):340–53.
24. Gale M., Darvell B. Thermal cycling procedures for laboratory testing of dental restorations. J Dent. 1999 Feb;27(2):89–99.

25. ISO/TS 11405:2015 , Dentistry – testing of adhesion to tooth structure. 3rd ed. Geneva S. ISO/TS 11405:2015 , Dentistry – testing of adhesion to tooth structure. 3rd ed. Geneva, Switzerland. 2015.

26. Ernst C-P, Cohnen U, Stender E, Willershausen B. In vitro retentive strength of zirconium oxide ceramic crowns using different luting agents. J Prosthet Dent. 2005 Jun;93(6):551–8.

27. Ernst C-P, Aksoy E, Stender E, Willershausen B. Influence of different luting concepts on long term retentive strength of zirconia crowns. Am J Dent. 2009 Apr;22(2):122–8.

28. Shahin R, Kern M. Effect of air-abrasion on the retention of zirconia ceramic crowns luted with different cements before and after artificial aging. Dent Mater. 2010 Sep 1;26(9):922–8.

29. Palacios RP, Johnson GH, Phillips KM, Raigrodski AJ. Retention of zirconium oxide ceramic crowns with three types of cement. J Prosthet Dent. 2006 Aug;96(2):104–14.

30. Gultekin P, Gultekin BA, Aydin M, Yalcin S. Cement Selection for Implant-Supported Crowns Fabricated with Different Luting Space Settings. J Prosthodont. 2013 Feb;22(2):112–9.