The Effects of New Design of Access Hole on Porcelain Fracture Resistance of Implant-Supported Crowns

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KEY WORDS
Dental Implants; Cement-retained; Fracture Resistance; Metal Ceramic Crowns

ABSTRACT
Statement of the Problem: One disadvantage of cement-retained crowns is the lack of predictable irretrievability. This problem can be overcome through designing a screw access hole in the metal substructure of cement-retained restoration and using porcelain stain to define this area.

Purpose: This study aimed to evaluate the influence of existence of screw access hole on porcelain fracture resistance of metal-ceramic implant-supported crowns.

Materials and Method: Thirty six standardized metal-ceramic crowns were fabricated and divided into 3 groups (n=12): group 1 conventional cement-retained metal-ceramic crowns as control group, group 2 cement-retained MC crowns in which porcelain stain was used to define the location of screw access channel, and group 3 cement-retained metal-ceramic crowns in the metal substructure of which a hole and ledge was designed in the location of screw access channel. The specimens were cemented (TempBond, Kerr) to their dedicated abutments. A hole was made in the location of screw access channel in group 2 and 3 and filled with photo-polymerized composite resin (3M; ESPE). All specimens were thermocycled and loaded in universal testing machine at crosshead speed of 2mm/min until fracture. Mean values of load at fracture were calculated in each group and compared with One-way ANOVA (α=0.05).

Results: Mean value of the load required to fracture the restorations was $1947\pm487$ N in group 1, $1927\pm539$ N in group 2, and $2170\pm738$ N in group 3. No statistically significant difference was found between the fracture resistance values of the three groups ($p>0.05$)

Conclusion: Presence of screw access channel in cement-retained implant restorations does not compromise fracture resistance.

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Cite this article as: Derafshi R., Farzin M., Taghva M., Heidary H., Atashkar B. The Effects of New Design of Access Hole on Porcelain Fracture Resistance of Implant-Supported Crowns. J Dent Shiraz Univ Med Sci., 2015 March; 16(1 Suppl): 61-67.
of ceramic-fracture or screw loosening). This feature also provides a better assessment of oral hygiene and peri-implant probing, as well as replacing the components in case of screw loosening or fracture. [16-18] However, the laboratory procedures required for screw-retained restorations are usually more sophisticated, expensive, and associated with inherent mechanical complications such as screw-loosening and fractures. [19-20] It is generally difficult and costly to remove and replace the fractured screws. [15]

Furthermore, natural occlusal morphology might be interfered due to the presence of a screw access opening. [21] which might also disrupt the porcelain continuity and lead to unstable occlusal contents. [22-23] As reported by a number of studies, presence of screw access opening in these restorations reduces the fracture resistance of the porcelain. [15, 22, 24-25] Among the advantages of cement-retained restorations are the lower costs of fabrication, facilitated procedure of implant restoratives, and a better passive fit, as well as preventing the interference of screw access opening with the esthetic or the occlusion of the restoration. [8, 25] Meanwhile, cement-retained restorations have some drawbacks including the difficulty in retrieving and removing the excess cement around the crown, in addition to cement loss which may lead to peri-implant inflammation. [15, 26-27]

Cement-retained restorations have been advised for treating partial edentulous patients with implant [16] and they are better to be the first treatment option when esthetic is concerned. [28] Besides, cement-retained implant prosthesis is chiefly concerned with the difficulty of being removed when the abutment screw has loosened or the porcelain has fractured and need to be corrected.

Literatures have suggested several methods to provide retrievability of cement-retained implant restorations; using provisional cement is one of them, although the retention may be damaged. [28] Placing a lingual retrieval slot at the abutment/prosthesis interface is another solution. [29] Other approaches are making use of ceramic stain on the occlusal surface of posterior restoration, [15] digital photographs or vacuum-formed templates to identify the position of screw. [30] In these methods, the screw channel is filled with composite resin when the restoration is removed. One concern is that, existence of screw channel in the framework may jeopardize the strength of restoration.

In the present study, a special feature was designed in the metal framework to support the remaining porcelain after the screw access channel was created. There is little data in the literature regarding the fracture resistance of cemented prostheses with screw access channel. The current investigation aimed to evaluate the influence of access hole in the occlusal surface of cement-retained implant restoration with and without specially designed feature on the fracture resistance of the restoration. The null hypothesis was that creating screw access on cement-retained crowns to permit retrievability would not compromise the strength of restoration.

Materials and Method
A 5×6.5 implant analog (Dio Corp.; Busan, Korea) was connected to a straight abutment. Then it was duplicated as 36 brass dies by using a lathe (CNC 350; Arix Co., Tainan Hesin, Taiwan). Then, five millimeters of each die was embedded vertically in an acrylic resin block with the aid of a dental surveyor (Figure 1).

![Figure 1: Brass die embedded in acrylic resin block](image_url)

Subsequently 36 metal ceramic crowns were fabricated with 3 designs; group 1 consisted of 12 conventional metal-ceramic crowns with cement-retained restorations as control group (Figure 2a); group 2 included 12 crowns with porcelain stain used to define the location of screw access channel (Figure 2b). Group 3 was constituted of 12 crowns during framework fabrication of which, a ledge was designed in wax-up in the location of screw access channel (Figure 2c). The ledge was 1.5 mm in height and 1 mm in thickness around a 2-mm hole in the center of occlusal surface (Figure 3). This area was defined in the crown by using porcelain stain.
Porcelain application to all specimens was standardized by using a silicone index. The crowns were then cemented on their dedicated master dies with zinc oxide-eugenol cement (TempBond; Kerr Mfg Co., Romulus, MI) in rocking motion and held in place with constant finger pressure until the cement set. The excess cement was removed using an explorer. A hole was made in the location of screw access channel in group 2 and 3 by using a 2-mm fissure bur on a high speed handpiece, and was filled with photo-polymerized composite resin (3M; ESPE Dental Products, Canada).

Finally, all specimens were thermocycled for 500 cycles between 50-65°C for 30 seconds with 12-second intervals according to the literature. [31-32] Each specimen was subjected to vertical compression load by using a universal testing machine (Zwick-Roell Z020; Zwick GmbH & Co. KG, Ulm, Germany) (Figure 4).
The force was applied perpendicular to the occlusal surface in the central part of the restoration with a cross-head speed of 2 mm/min. In order to simulate the contact established by the opposing tooth, the rounded edges of the loading pin simultaneously contacted the triangular ridges of both buccal and lingual cusps of the crowns (Figure 5). The specimens were loaded to failure. Maximum values of loads at failure were recorded for each specimen. Mean values of fracture resistance for all groups were calculated and compared by using one-way ANOVA. The level of statistical significance was set at $\alpha=0.05$.

### Results

The mean fracture resistance value was 2190±738 N in group 3 (special design), 1928±539 N in group 2 and 1947±487 N in control group (Table 1). No statistically significant difference was detected among the three groups regarding the fracture resistance value ($p=0.491$).

### Discussion

With respect to the obtained results of the present study, the null hypothesis cannot be rejected. The fracture resistance of specially designed cement-retained crowns with screw access was higher than the other two groups; this difference was not significant though ($p>0.05$).

Zarone et al. [23] evaluated the fracture resistance of screw-retained versus cement-retained single metal-ceramic crowns. They found no significant difference between the two groups. However, fracture resistance values of cement-retained crowns were higher; which is in accordance with the results of the current study.

In another study, Karl et al. [32] observed more chipping fractures in screw-retained fixed dental prostheses than cemented models. They did not fill the access opening with any materials. The authors proposed filling the access hole with intraoral ceramic-repair resin composites to stabilize the occlusal surface of screw-retained implant restorations.

Several studies [22, 32-34] revealed the fracture resistance of screw-retained restorations with screw access hole to be less than cement retained restorations. The difference between the results obtained by the current study and other studies can be attributed to the cementing of the specimens. In the present study, the specimens were cement-retained with an access hole, while in other studies the specimens were screw-retained with an access hole which might had contained a screw or not. Other reasons that justify the difference in results could be related to the different procedures of fabricating the specimens, different sizes of screw access opening, filling the access hole with composite resin or leaving it unfilled, the type of resin repair system used, the type and cycles of force used for loading, the area on which the force was applied, luting the restorations or not, and the type of cement which was used. It should be noted that the minimum load which caused fracture in specimens in the aforementioned studies was more than the maximum masticatory forces. [35] Therefore, both types of the restorations can be considered predictable in the implant prosthetic restoration phase.

The especially cement-retained design proposed

### Table 1: Fracture load (newton) of the three groups

|        | N | Mean | SD  | Min  | Max  |
|--------|---|------|-----|------|------|
| Group 1| 12| 1947 | 487 | 1370 | 3120 |
| Group 2| 12| 1928 | 539 | 766  | 2610 |
| control| 12| 2190 | 738 | 1210 | 3810 |

*Standard deviation
in the present study offered the advantages of cement-
retained restorations in conjunction with the likelihood
of the restoration retrievability. Furthermore, according
to the study of Rocha et al., screw access hole in
cement-retained implant restoration had not any nega-
tive influence on the retention. [36]

There were some limitations in the present study,
one of which was the single static force that was used
to load the specimens and it differed from the dynamic
load in the oral environment. In mouth, the restoration
may also fracture due to fatigue loading. [37] In the
present study, the crowns were cemented using zinc
oxide-eugenol cement which is used more clinically
and no permanent cement was tested.

Future researchers are recommended to investi-
gate larger sample sizes under physiologic fatigue
loading. Employing different types of cements for lut-
ing the specimens is also advised.

Conclusion
Within the limitations of this study, the following con-
clusions are drawn:
• Presence of screw access opening in cement-
retained implant restoration would not compro-
mise the fracture resistance.
• Designing a ledge in the framework of cement-
retained implant restorations in the location of
screw access opening could be a useful method to
retrieve restoration, without compromising its
strength.

Acknowledgements
The authors thank the Vice-Chancellery of Shiraz
University of Medical Sciences for supporting this
research study (Grant#92-01-03-5988). The article is
based on a thesis by Dr. Hosein Heidary. The authors
also would like to thank Dr. Vosoughi from the Dental
Research Development Center, School of Dentistry,
Shiraz University of Medical Sciences for his contribu-
tions in the process of statistical analyses.

Conflicting Interest
The authors declare no conflict of interest.

References
[1] Moraschini V, Poubel LA, Ferreira VF, Barboza Edos S.
Evaluation of survival and success rates of dental im-
plants reported in longitudinal studies with a follow-up
period of at least 10 years: a systematic review. Int J
Oral Maxillofac Surg 2015; 44: 377-388.
[2] Kwon T, Bain PA, Levin L. Systematic review of short-
(5-10 years) and long-term (10 years or more) survival
and success of full-arch fixed dental hybrid prostheses
and supporting implants. J Dent 2014; 42: 1228-1241.
[3] Attard NJ, Zarb GA. Implant prosthodontic manage-
ment of partially edentulous patients missing posterior
teeth: the Toronto experience. J Prosthet Dent 2003; 89:
352-359.
[4] Ozkan Y, Ozcan M, Akoglu B, Ucankale M, Kulak-
Ozkan Y. Three-year treatment outcomes with three
brands of implants placed in the posterior maxilla and
mandible of partially edentulous patients. J Prosthet
Dent 2007; 97: 78-84.
[5] Hofstede TM, Ercoli C, Hagan ME. Alternative com-
plete-arch cement-retained implant-supported fixed par-
tial denture. J Prosthet Dent 1999; 82: 94-99.
[6] Ekfeldt A, Carlsson GE, Börjesson G. Clinical evalua-
tion of single tooth restorations supported by osseoin-
tegrated implants: a retrospective study. Int J Oral Max-
illofac Implants 1994; 9: 179-183.
[7] Becker W, Becker BE. Replacement of maxillary and
mandibular molars with single endosseous implant res-
 torations: a retrospective study. J Prosthet Dent 1995;
74: 51-55.
[8] Taylor TD, Agar JR. Twenty years of progress in im-
plant prosthodontics. J Prosthet Dent 2002; 88: 89-95.
[9] Levine RA, Clem D, Beagle J, Ganeles J, Johnson P,
Sol-nit G, et al. Multicenter retrospective analysis of the
solid-screw ITI implant for posterior single-tooth re-
placements. Int J Oral Maxillofac Implants 2002; 17:
550-556.
[10] Andersson B, Odman P, Lindvall AM, Brännemark PI.
Cemented single crowns on osseointegrated implants
after 5 years: results from a prospective study on Cer-
aOne. Int J Prosthodont 1998; 11: 212-218.
[11] Kerstein RB, Castellucci F, Osorio J. Ideal gingival
form with computer-generated permanent healing
abutments. Compend Contin Educ Dent 2000; 21: 793-
797.
[12] Adell R. Clinical results of osseointegrated implants
supporting fixed prostheses in edentulous jaws. In: Zarb
GA, editor. (ed.) Proceedings of Toronto conference on
osseointegration in clinical dentistry. St. Louis, MO: Mosby; 1983. p. 1-165.

[13] Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants 1986; 1: 11-25.

[14] Brånemark PI, Svensson B, van Steenberghhe D. Ten-year survival rates of fixed prostheses on four or six implants ad modum Brånemark in full edentulism. Clin Oral Implants Res 1995; 6: 227-231.

[15] Chee W, Felton DA, Johnson PF, Sullivan DY. Cemented versus screw-retained implant prostheses: which is better? Int J Oral Maxillofac Implants 1999; 14: 137-141.

[16] Michalakis KX, Hirayama H, Garefis PD. Cement-retained versus screw-retained implant restorations: a critical review. Int J Oral Maxillofac Implants 2003; 18: 719-728.

[17] Rajan M, Gunaseelan R. Fabrication of a cement- and screw-retained implant prosthesis. J Prosthet Dent 2004; 92: 578-580.

[18] Farina AP, Spazzin AO, Pantoja JM, Consani RL, Mesquita MF. An in vitro comparison of joint stability of implant-supported fixed prosthetic suprastructures retained with different prosthetic screws and levels of fit under masticatory simulation conditions. Int J Oral Maxillofac Implants 2012; 27: 833-838.

[19] McGlumphy EA, Mendel DA, Holloway JA. Implant screw mechanics. Dent Clin North Am 1998; 42: 71-89.

[20] Pietrabissa R, Gionso L, Quaglini V, Di Martino E, Simion M. An in vitro study on compensation of mismatch of screw versus cement-retained implant supported fixed prostheses. Clin Oral Implants Res 2000; 11: 448-457.

[21] Hebel KS, Gajjar RC. Cement-retained versus screw-retained implant restorations: achieving optimal occlusion and esthetics in implant dentistry. J Prosthodont 1997; 77: 28-35.

[22] Torrado E, Ercoli C, Al Mardini M, Graser GN, Talents RH, Cordaro L. A comparison of the porcelain fracture resistance of screw-retained and cement-retained implant-supported metal-ceramic crowns. J Prosthodont 2004; 91: 532-537.

[23] Zaron F, Sorrentino R, Traini T, Di Iorio D, Caputi S. Fracture resistance of implant-supported screw- versus cement-retained porcelain fused to metal single crowns: SEM fractographic analysis. Dent Mater 2007; 23: 296-301.

[24] Engquist B, Nilson H, Astrand P. Single-tooth replacement by osseointegrated Brånemark implants. A retrospective study of 82 implants. Clin Oral Implants Res 1995; 6: 238-245.

[25] Guichet DL, Caputo AA, Choi H, Sorensen JA. Passivity of fit and marginal opening in screw- or cement-retained implant fixed partial denture designs. Int J Oral Maxillofac Implants 2000; 15: 239-246.

[26] Kent DK, Koka S, Froeschle ML. Retention of cemented implant-supported restorations. J Prosthodont 1997; 6: 193-196.

[27] Breeding LC, Dixon DL, Bogacki MT, Tietge JD. Use of luting agents with an implant system: Part I. J Prosthodont 1992; 68: 737-741.

[28] Covey DA, Kent DK, St Germain HA Jr, Koka S. Effects of abutment size and luting cement type on the uniaxial retention force of implant-supported crowns. J Prosthodont 2000; 83: 344-348.

[29] Schweitzer DM, Berg RW, Mancia GO. A technique for retrieval of cement-retained implant-supported prostheses. J Prosthodont 2011; 106: 134-138.

[30] Daher T, Morgan SM. The use of digital photographs to locate implant abutment screws for implant-supported cement-retained restorations. J Prosthodont 2008; 100: 238-239.

[31] Braden M. Heat conduction in normal human teeth. Arch Oral Biol 1964; 9: 479-486.

[32] Karl M, Graef F, Taylor TD, Heckmann SM. In vitro effect of load cycling on metal-ceramic cement- and screw-retained implant restorations. J Prosthodont 2007; 97: 137-140.

[33] Warpeha WS Jr, Goodkind RJ. Design and technique variables affecting fracture resistance of metal-ceramic restorations. J Prosthodont 1976; 35: 291-298.

[34] Al-Omari WM, Shadid R, Abu-Nab&aacute;a L, El Masoud B. Porcelain fracture resistance of screw-retained, cement-retained, and screw-cement-retained implant-supported metal ceramic posterior crowns. J Prosthodont 2010; 19: 263-273.

[35] Braun S, Hnat WP, Freudenthaler JW, Marcotte MR, Hönigle K, Johnson BE. A study of maximum bite force during growth and development. Angle Orthod 1996; 66: 261-264.

[36] da Rocha PV, Freitas MA, de Morais Alves da Cunha
T. Influence of screw access on the retention of cement-retained implant prostheses. J Prosthet Dent 2013; 109: 264-268.

[37] Pallis K, Griggs JA, Woody RD, Guillen GE, Miller AW. Fracture resistance of three all-ceramic restorative systems for posterior applications. J Prosthet Dent 2004; 91: 561-569.