ADVANCES IN BIORESEARCH
Adv. Biores., Vol 8 [3] May 2017: 205-208

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.8.3.205208

Advances in Bioresearch

REVIEW ARTICLE

Fracture Resistance of Zirconia Fixed Partial Dentures

Vahideh Nazari[a], Mohammed Hussein Alsharbaty[a], Moeen Hosseini Shirazi[a*]
[a]Post-graduate Student, Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.
*Corresponding author: Moeen Hosseini Shirazi
Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran, North Karegar st, Tehran, , Iran. Postal code: 14399-55991
E-mail: Moeen.hshirazi@yahoo.com, Tel: +989113554859, Fax: +982188015801

ABSTRACT
Over the past decades, attention in more esthetically pleasing and metal free restoration has amplified for all ceramic restorations. Additionally, numerous systems are provided to employ sophisticated CAD/CAM technology. After the innovation in zirconia material, new sight of lights provided for designing fixed all-ceramic partial dentures without limitation of the fixed partial denture' size. Therefore, the aim of the current research was to determine fracture resistance of zirconia FPDs using the PubMed and Medline database English literature by the terms: "Fracture resistance", "Zirconia", "Fixed partial dentures" and "framework design" and "occlusal forces".
Keywords: *Zirconia, CAD/CAM, FPDs*

Received 19.03.2017 Revised 04.04.2017 Accepted 29.04.2017

How to cite this article:
V Nazari, M H Alsharbaty, M H Shirazi. Fracture Resistance of Zirconia Fixed Partial Dentures. Adv. Biores., Vol 8 [3] May 2017.205-208

INTRODUCTION

Metal-ceramic restorations represent the desirable and efficacious treatment modality. Clinical trials have shown that metal-ceramic FPDs have ability of long lasting [1]. Nonetheless, metal frameworks have inherent disadvantages include material corrosion and discoloration of gingival tissues adjacent to the crown margins [2]. In comparison to the metals, dental ceramics has enhanced biocompatibility and improved esthetics (3). Capability of transmission of light through the ceramic mass provides such a promising property to it. Additionally, dental ceramics exhibit lessened plaque accumulation, low thermal conductivity, resistance to corrosion and color stability. Inadequate mechanical strength and stability caused by brittleness as well as low tensile strength of these materials limit their range of indication [3]. Zirconia copings, which are fabricated by computer-aided design/computer-aided manufacturing (CAD/CAM) has been developed accurately with high mechanical strength [4].

Yttria-tetragonal-zirconia-polycrystal (Y-TZP) was introduced in 2002, as a framework material. The Y-TZP indicated for all-ceramic FDPs there are growing interest for other clinical applications [5]. Because of high strength and fracture toughness associated with favorable optical and bio computability, Y-TZP considered being a worthy alternative to metal in FPDs [6]. Mechanical property of Y-TZP is higher compared to all other ceramics for dental use. It is reported that Y-TZP zirconia has fracture toughness of 6–10MPa, a flexural strength of 900–1200 MPa and a compression resistance of 2000 MPa [7]. The high strength of the Y-TZP was attributed to a phase transformation toughening mechanism. This involves the transformation of metastable tetragonal grains (t) to the monoclinic phase (m) under stress at the crack tip, which, accompanied by volume expansion, induces compressive stresses that counteract crack propagation [8]. At the edge of the crack, the compressive stress transformed tetragonal grains counteracts the tensile stress field and stimulates the propagation of the crack and finally inhibits further propagating of the crack [9].

Two major techniques introduced for fabrication of Y-TZP frameworks. In the first method milling enlarged frameworks out of homogenous blanks, which are typically carried out by a nonsintered (green

body) or in different presintered stages. Then milled frameworks sintered and shrunk to the desired dimensions [10-13]. The second technique contains milling the frameworks directly with the final dimensions out of highly dense sintered prefabricated blanks [10-12, 14].
In clinical research on the 3 to 5-unit FDPs revealed short-term (2-3 years) follow-up of zirconia-based posterior FDPs. It is reported the survival rates of this system is higher than 85 percent [15-17].
This review article describes the fracture resistance of zirconia-based fixed restorations, including results of current in vitro studies and the clinical performance of these restorations. An electronic search has been conducted, during 2016, via PubMed and Medline database English literature. Peer-reviewed articles were targeted following key-words have been used: Fracture resistance", "Zirconia", "Fixed partial dentures" and "framework design and occlusal forces. Available full-text articles were read. Related articles were also scrutinized. Hand search was also driven.

STUDIES ON FRACTURE RESISTANCE OF ZIRCONIA FPDs

To our knowledge, frequent researches were done to determine the fracture resistance of ZrO2-based FPDs [13, 18-20]. Because of the mechanical properties of zirconia, it is possible to use in posterior FPDs and permit substantial reduction in core thickness (11). Mechanical strength of zirconia frameworks is 3 times greater than other all ceram. SO, it is able to withstand physiological occlusal forces applied in the posterior region [21-24]. However, the cracking is still as a major disadvantage of zirconia restorations. For instance, the Porcelain chipping of the zirconia restorations rates up to 20% in 5-years period [23, 25].
Based on the *in vitro* studies that stresses induced in the cervical portion of an all-ceramic FPD supported by chamfer preparations during loading and might affect the connector areas. In this area the stress concentration can reach critical levels and terminate to the FPD to fracture. So, it is suggested that all-ceramic FPDs cemented non-adhesively should be supported by shoulder preparations to resist extensive loading whenever it may be expected [26].

Failure mode of the zirconia FPDs

According to the *in vitro* and *in vivo* studies, the highest failures were found in the connector area in all-ceramic FDPs. It propagated obliquely, connecting the gingival embrasure of the connector and the occlusal loading point on the pontic [24, 27-31]. The line of crack propagation relates to the stress localization. According to the prior finite element analysis and photoelastic reports [27, 28] the gingival surface of both connectors is initially in highest tension, whereas the occlusal surface of the abutment side of the gingival connector, as well as the loading point on the pontic, are in maximum compression. Ceramic materials enable to withstand to occlusal forces better than tensile forces and leads to the fracture the restorations.

Effect of the framework design

The framework design can affect Fracture strength [32, 33]. The effects of framework design on fracture strength of zirconia restorations are fully studied [5, 29, 34-37]. Fracture load for zirconia-based all ceramic restorations with anatomically designed frameworks was higher than uniform thickness frameworks [4, 32]. It is claimed the resistance might related to the thinner layer of layering material and adequate support of layer by the supported zirconia framework at the occlusal surface [32, 33]. Furthermore, the fracture resistance of the zirconia posterior FPDs affected by the connector size and shape [5, 19]. Smaller cross sectional area of connectors, the needed load for fracture of core will be decreased [19]. In this regard, Plengsombut et al, shown that higher maximum failure loads were found for the round connector design compared to the sharp connector design for ZirCAD and CAD (5). Furthermore, Sundh et al, reported that mean fracture resistance of groups with 4×4 mm connector was higher than 3 ×3 mm connector [19].

Potential to withstand occlusal forces

Dental restorations are subjected to intermittent occlusal forces during mastication and swallowing. The chewing frequency and the places of maximal force on the occlusal surface were relatively constant [38]. The forces exerted on the occlusal surface seldom exceeded 10 to 15 pounds in normal chewing [38]. Also, the maximum bite forces that the stomatognathic system can exert in the posterior area (300 to 880N) for the first molar [39, 40]. Some bruxers and clenchers present bite forces six-times higher than that of non-bruxers [40], while Patients with symptoms of dysfunction of the masticatory system show lower bite forces that increase as the symptoms disappear (41) Additionally there are difference for biting forces among male and female where 807N for males and 650N for females in the molar region [42]. The biting force decrease with increasing age, because of the age-dependent deterioration of the dentition [41]. Zirconia FPDs have the vital role to withstand occlusal forces applied in the posterior region. So, represent interesting alternatives to replace metal-ceramic restorations [22, 43].

CONCLUSION

Today, all-ceramic restorations are becoming more popular because of material improvements and advances in fabrication technologies. CAD/CAM technology, it is possible now to use new high-strength ceramic materials to fabricate all-ceramic restorations with higher and uniform material quality, standardized manufacturing processes and reduced production costs. Limited number of short-term clinical studies on posterior Y-TZP-based FPDs showed success rates of 100% with observation periods between 2-3 years. Further assessments are needed before recommending these restorations for daily practice [1].

REFERENCES

1. Walton TR. (2002). An up to 15-year longitudinal study of 515 metal-ceramic FPDs: Part 1. Outcome. Int J Prosthodont. ;15(5):439-45.
2. Riley EJ. (1977).Ceramo-metal restoration. State of the science. Dent Clin North Am. 21(4):669-82.
3. Campbell SD, Sozio RB. (1988). Evaluation of the fit and strength of an all-ceramic fixed partial denture. J Prosthet Dent. ;59(3):301-6.
4. Kokubo Y, Tsumita M, Kano T, Fukushima S. (2011). The influence of zirconia coping designs on the fracture load of all-ceramic molar crowns. Dent Mater J;30(3):281-5.
5. Plengsombut K, Brewer JD, Monaco EA, Jr., Davis EL. (2009). Effect of two connector designs on the fracture resistance of all-ceramic core materials for fixed dental prostheses. J Prosthet Dent. 101(3):166-73.
6. Mainjot AK, Najjar A, Jakubowicz-Kohen BD, Sadoun MJ. (2015). Influence of thermal expansion mismatch on residual stress profile in veneering ceramic layered on zirconia: Measurement by hole-drilling. Dent Mater.;31(9):1142-9.
7. Zarone F, Russo S, Sorrentino R. (2011). From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. Dent Mater. 27(1):83-96.
8. Piconi C, Maccauro G. (1999). Zirconia as a ceramic biomaterial. Biomaterials.;20(1):1-25.
9. Piconi C, Burger W, Richter HG, Cittadini A, Maccauro G, Covacci V, et al. (1998). Y-TZP ceramics for artificial joint replacements. Biomaterials.;19(16):1489-94.
10. Raigrodski AJ. (2009). Contemporary materials and technologies for all-ceramic fixed partial dentures: a review of the literature. J Prosthet Dent.;92(6):557-62.
11. Denry I, Kelly JR. (2008). State of the art of zirconia for dental applications. Dent Mater. ;24(3):299-307.
12. Sadan A, Blatz MB, Lang B. (2005). Clinical considerations for densely sintered alumina and zirconia restorations: part 2. Int J Periodontics Restorative Dent.;25(4):343-9.
13. Filser F, Kocher P, Weibel F, Luthy H, Scharer P, Gauckler LJ. (2001). Reliability and strength of all-ceramic dental restorations fabricated by direct ceramic machining (DCM). Int J Comput Dent. 4(2):89-106.
14. Vult von Steyern P. All-ceramic fixed partial dentures. Studies on aluminum oxide- and zirconium dioxide-based ceramic systems. Swed Dent J Suppl. 2005(173):1-69.
15. Sailer I, Feher A, Filser F, Luthy H, Gauckler LJ, Scharer P, et al. Prospective clinical study of zirconia posterior fixed partial dentures: 3-year follow-up. Quintessence Int. 2006;37(9):685-93.
16. Raigrodski AJ, Chiche GJ, Potiket N, Hochstedler JL, Mohamed SE, Billiot S, et al. (2006). The efficacy of posterior three-unit zirconium-oxide-based ceramic fixed partial dental prostheses: a prospective clinical pilot study. J Prosthet Dent. 96(4):237-44.
17. Vult von Steyern P, Carlson P, Nilner K. (2005). All-ceramic fixed partial dentures designed according to the DC-Zirkon technique. A 2-year clinical study. J Oral Rehabil. 32(3):180-7.
18. Luthy H, Filser F, Loeffel O, Schumacher M, Gauckler LJ, Hammerle CH. (2005). Strength and reliability of four-unit all-ceramic posterior bridges. Dent Mater.;21(10):930-7.
19. 19. Sundh A, Molin M, Sjogren G. (2005). Fracture resistance of yttrium oxide partially-stabilized zirconia all-ceramic bridges after veneering and mechanical fatigue testing. Dent Mater. 21(5):476-82.
20. Sundh A, Sjogren G. (2006). Fracture resistance of all-ceramic zirconia bridges with differing phase stabilizers and quality of sintering. Dent Mater. 22(8):778-84.
21. Komine F, Blatz MB, Matsumura H. (2010). Current status of zirconia-based fixed restorations. J Oral Sci.;52(4):531-9.
22. Att W, Grigoriadou M, Strub JR. (2007). ZrO2 three-unit fixed partial dentures: comparison of failure load before and after exposure to a mastication simulator. J Oral Rehabil. ;34(4):282-90.
23. Vult von Steyern P, Jonsson O, Nilner K. (2001). Five-year evaluation of posterior all-ceramic three-unit (In-Ceram) FPDs. Int J Prosthodont. 2;14(4):379-84.
24. Tinschert J, Natt G, Mautsch W, Augthun M, Spiekermann H. (2001). Fracture resistance of lithium disilicate-, alumina-, and zirconia-based three-unit fixed partial dentures: a laboratory study. Int J Prosthodont. ;14(3):231-8.
25. Probster L. (1993). Survival rate of In-Ceram restorations. Int J Prosthodont. ;6(3):259-63.
26. Vult von Steyern P, al-Ansari A, White K, Nilner K, Derand T. (2000). Fracture strength of In-Ceram all-ceramic bridges in relation to cervical shape and try-in procedure. An in-vitro study. Eur J Prosthodont Restor Dent.;8(4):153-8.

27. Kou W, Kou S, Liu H, Sjogren G. (2007). Numerical modeling of the fracture process in a three-unit all-ceramic fixed partial denture. Dent Mater.23(8):1042-9.
28. Oh W, Gotzen N, Anusavice KJ. (2002). Influence of connector design on fracture probability of ceramic fixed-partial dentures. J Dent Res. ;81(9):623-7.
29. Oh WS, Anusavice KJ. (2002). Effect of connector design on the fracture resistance of all-ceramic fixed partial dentures. J Prosthet Dent. 87(5):536-42.
30. Taskonak B, Sertgoz A.(2006). Two-year clinical evaluation of lithia-disilicate-based all-ceramic crowns and fixed partial dentures. Dent Mater. 22(11):1008-13.
31. Kelly JR, Tesk JA, Sorensen JA. (1995).Failure of all-ceramic fixed partial dentures in vitro and in vivo: analysis and modeling. J Dent Res.;74(6):1253-8.
32. Kamio S, Komine F, Taguchi K, Iwasaki T, Blatz MB, Matsumura H. (2015). Effects of framework design and layering material on fracture strength of implant-supported zirconia-based molar crowns. Clin Oral Implants Res. ;26(12):1407-13.
33. Larsson C, El Madhoun S, Wennerberg A, Vult von Steyern P. (2012). Fracture strength of yttria-stabilized tetragonal zirconia polycrystals crowns with different design: an in vitro study. Clin Oral Implants Res. ;23(7):820-6.
34. Salimi H, Mosharraf R, Savabi O. (2012). Effect of framework design on fracture resistance of zirconium oxide posterior fixed partial dentures. Dent Res J (Isfahan).;9(6):764-9.
35. Takuma Y, Nomoto S, Sato T, Sugihara N. (2013).Effect of framework design on fracture resistance in zirconia 4-unit all-ceramic fixed partial dentures. Bull Tokyo Dent Coll. ;54(3):149-56.
36. Salimi H, Mosharraf R, Savabi O. (2012).Effect of framework design on fracture resistance of zirconium oxide posterior fixed partial dentures. Dental Research Journal. 9(6):764-9.
37. Kokubo Y, Tsumita M, Sakurai S, Torizuka K, Vult von Steyern P, Fukushima S. (2007). The effect of core framework designs on the fracture loads of all-ceramic fixed partial dentures on posterior implants. J Oral Rehabil. ;34(7):503-7.
38. De Boever JA, McCall WD, Jr., Holden S, Ash MM, Jr. (1978). Functional occlusal forces: an investigation by telemetry. J Prosthet Dent. ;40(3):326-33.
39. Bates JF, Stafford GD, Harrison A. (1975). Masticatory function-a review of the literature: (II) Speed of movement of the mandible, rate of chewing and forces developed in chewing. J Oral Rehabil.;2(4):349-61.
40. Gibbs CH, Mahan PE, Mauderli A, Lundeen HC, Walsh EK. (1986). Limits of human bite strength. J Prosthet Dent.;56(2):226-9.
41. Helkimo E, Carlsson GE, Helkimo M. (19977). Bite force and state of dentition. Acta Odontol Scand.;35(6):297-303.
42. Kiliaridis S, Kjellberg H, Wenneberg B, Engstrom C. (1993). The relationship between maximal bite force, bite force endurance, and facial morphology during growth. A cross-sectional study. Acta Odontol Scand. ;51(5):323-31.
43. Att W, Stamouli K, Gerds T, Strub JR. (2007). Fracture resistance of different zirconium dioxide three-unit all-ceramic fixed partial dentures. Acta Odontol Scand.;65(1):14-21.