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ORIGINAL ARTICLE

A comparative evaluation of marginal fit of all ceramic crowns fabricated with zirconia cored crowns and monolithic crowns – An *in vitro* study

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Abstract

Background: Marginal fit is a very important factor considering the restoration's long-term success. Because of poor marginal fit of the crowns, there will be exposure of luting material into the oral environment and causes secondary caries. The purpose of this study was to compare the marginal fit of three all-ceramic crowns, zirconia copings, and zirconia coping with layering and monolithic crowns.

Aim: This study aims to evaluate marginal fit of all-ceramic crowns fabricated with zirconia cored crowns and monolithic crowns.

Materials and Methods: From a standardized die of a prepared tooth, 30 dies were poured with type IV gypsum product. The 30 dies were divided into three groups. First group was zirconia coping as Group I. Zirconia copings were veneered as Group II. Monolithic crowns as Group III were fabricated on the dies with 10 samples in each group 10 crowns were cemented with resin cement. Marginal fit of sectioned crowns was measured using stereomicroscope. Six points were compared in all Groups I, II, and III.

Results: Marginal fit of monolithic crown has better marginal fit than zirconia coping with layering.

Conclusion: It was concluded that mean marginal fit of zirconia copings Group I, zirconia copings with veneering and monolithic crowns Group III significantly differs.

Introduction

One of the fixed treatment options for patients needing replacement of restoration is metal ceramic crown. The advantages of strength, esthetics, and cost affordability have made it a common material choice among many practicing dentists in a developing country like India.[1] The increasing interest in more esthetically pleasing restorations over the past few years has led to the development of all-ceramic crown systems. Fixed prosthodontics, being the first common prosthodontic treatment option from time immemorial, had a face lift in the past few decades, with the advent of all ceramic restoration.[2] In the infantile era of all ceramic restorations, crowns were made on a platinum matrix and were referred to as porcelain jacket crowns.[3] More recently, improved materials and techniques have been introduced in an attempt to overcome the disadvantages inherent in that traditional method. All-ceramic inlays, onlays, veneers, and crown provide some of the most esthetically pleasing restorations currently available.[4] They can be made to match natural tooth structure accurately in terms of color, surface texture, and translucency.

Well-made all-ceramic restorations can be virtually indistinguishable from unrestored natural teeth. They are more widely accepted because of its excellent biocompatibility, magnetic resonance imaging, and computed tomography compatibility.[5] These improvements, particularly the use of higher strength ceramics and adhesives for bonding the ceramic restoration to tooth structure, have led to a resurgence of interest in all-ceramic restorations, including the more conservative inlays and veneers.

Glass ceramics were used as an anterior restorative material as crowns, due to its excellent life like translucency, but reported to have lower strength.[6] Newer materials such as alumina and zirconia have got better strength for posterior restorations but have less translucency for anterior restorations.[7] Zirconia ceramics are superior to other ceramics in bending strength and fracture toughness, and yttrium oxide partially stabilized zirconia (Y-TZP) is used as reinforced zirconia with its own advantages. The metal-like behavior of this ceramic material is unique among the other ceramics which are used for dental restorations.[8]

The different techniques used for all ceramic systems are the heat-press and computer-aided design and manufacturing (CAD/CAM) system.[9] CAD/CAM system means that a major part in the working sequence is carried out by industrial machine.[10] The milling involves fabrication of a substructure with zirconia or the entire unit(s) could be machined. The machinable ceramics fabricated, offer a great advantage over conventional processing by eliminating clinical steps in impression making and laboratory steps including cast pouring, articulation, die sectioning, casting, and subsequent layering, thus saving enormous amount of time and, workforce, but the superiority of this system over the conventional layered ceramics, with effect to marginal discrepancy, is not clearly established in the literature.[11]

Based on the methods of image scanning and milling substructure, reinforced restoration, namely, the CAD/CAM addition direct metal laser sintering (DMLS) and subtraction (milling method) is commonly used.[12] These materials are used in combination with layered aluminous porcelain to be made stronger and more esthetic. The marginal fit is one of the most important criteria for long-term success of all-ceramic restorations.[13] Marginal fit of the crown can be assessed by various means in the literature. One such method could be by measuring the discrepancy in terms of a gap between the abutment and inner surface of the restoration.[14] Discrepancy in marginal fit can facilitate microleakage, salivary infiltration, pulpal and periodontal tissues, marginal seal, fracture resistance, and seepage resulting in dissolution of luting cement, thus increasing the susceptibility for secondary caries around the abutment eventually leading to abutment and restoration failure.[15] Other factors such as the effect on pulpal and periodontal tissues, marginal seal, fracture resistance, and esthetics are important criteria for the long-term success of all ceramic crowns.[16]

Mclean suggested restoration with marginal gap <120 μm more likely to be successful.[17] There are various factors such as type of finish lines, die spacing, die material, choice of restorative materials, manipulation and processing technique, cementation procedures, and luting agents which could influence this phenomenon.[18]

Polyvinyl siloxane remained major choice of elastomeric impression material for fixed partial restoration for a long period of time, due to its accuracy and dimensional stability. Resin cement offer improved properties and less technique sensitivity than traditional cements.[19] Therefore, they are excellent choices for the cementation of appropriate ceramic restorations. Self-adhesive resin cements have been used to cement all-ceramic restorations because of low solubility. Resin-based cements are basically constituted from photoinitiator substances, pigments, and small monomers.[20]

There were only limited studies present for the comparison between marginal fit zirconia coping and zirconia coping with layering and monolithic crowns. Hence, the following research question was raised.

Materials and Methods

Cobalt chromium metal die is fabricated in CAD/CAM using classic tooth preparation specifications [Figure 1]. Cobalt chromium metal die is designed using software [Figure 2]. The design specification of dies includes 6° taper mesiodistally and 6° taper buccolingually with a circumferential shoulder of 1.0 mm and height of 5 mm. The occlusal reduction was 1.5 mm, measured in the deepest point of the main fissure and axial reduction of 1 mm the die base should be flat and cylindrical in shape with diameter of 10 mm and height of about 15 mm from the finish line to the base. A base was made for the metal die.[21]

A custom-made self-cure tray was made for impression making of the metal die. The elastomeric impression (polyvinyl siloxane – FLEXEED – GC) was made using putty-wash

Figure 1: Metal die

Figure 2: Computer-aided design and computer-aided manufacturing milling unit

technique. The light body impression material was used in an automixing injectable gun. Before making each impression, the surface of the metal die was cleaned. Specimens of metal die were prepared by compressing the impression material between a custom-made stainless steel and self-cure tray. Thirty specimens were made from 30 impressions of the die. Thirty impressions were poured with the die stone (Pearl stone, Asian Chemicals, Survey no 236, Rajkot, India) using following the manufacturer's recommended settings for the water-powder ratio. It was mixed uniformly without creating air bubbles and then poured into the impressions which were placed over vibrator. After the setting time of the die stone of 45 min as per the manufacturer instructions, the die was separated from the impressions.[22] Thirty dies were divided into three groups, in which 10 crowns were made as zirconia copings (Group I), 10 crowns were made using zirconia coping and ceramic veneering (Group II), and 10 crowns were made as monolithic crowns (Group III) fabricated in a private dental laboratory (Sri Ram Dental Lab, Dindigul). Standard protocols by a single operator were followed for layering of zirconia coping. Crowns in the zirconia group had a zirconia substructure fabricated using CAD/CAM technology and a veneer layer of 1.0 mm uniform thickness at its minimum from the central fossa of the substructure is fabricated using ceramic hand layering technique using (Ivoclar Vivadent).[23]

Fabrication of zirconia crowns

Thirty dies were numbered and scanned in 3M ESPE optical scanner (Shining 3D Scanner DS 200) and data were transferred to the Modellier software (SYNTEC, G54, Germany), using zirconia blanks (METOXIT, Switzerland). The built-in-lab software automatically positioned several restorations within a single ceramic block and helped to edit model data, insert saw cuts, and refine the preparation margin. The five axis milling device with three spatial axis was used in the study. Thirty zirconia coping was milled as Group I zirconia coping by CAD-CAM milling unit (SYNTEC G54 MDI BLOCKNO L1 CAD/CAM M5 Milling unit, Germany) to a uniform thickness. Ten specimens were zirconia coping made as Group I [Figure 3]. Then, 10 zirconia copings were veneered as (Group II), the zirconia substructure was made resembling the size and anatomy to each other as closely as possible using layering technique maintaining the minimum and maximum dimensions of the layered material. The veneering thickness should be 1.0 mm. Ten zirconia monolithic crowns as Group III were milled using CAD-CAM milling unit (SYNTEC G54 MDI BLOCKNO L1, CAD/CAM M5 Milling unit, Germany) to a uniform thickness. All the 30 crowns were separated into 10 per group in their respective models and prepared for cementation. All crowns were luted to their respective dies using resin cement (G-CEM LinkAce). All the crowns were luted to their respective dies using Self- adhesive resin cement [G-CEM LinkAce] [Self Adhesive resin cement, Translucent LOT 1504221 GC Corporation, Tokyo, Japan] and the cemented crowns were placed under static load of 50N for 5 minutes. The

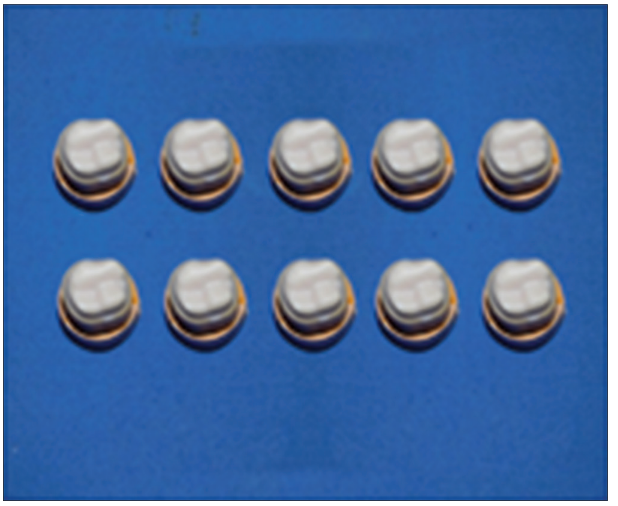

Figure 3: Dies with zirconia crowns

luted crowns were light cured for about 2 min.[24] The zirconia was placed in the vice of X-axis of the grinding machine and gradual force where gives for sectioning of the zirconia crowns in mesial and distal aspect. The sectioned zirconia crowns were placed in the stereomicroscope[25] [Figure 4] (Serial no; 5737312 Leica: DFC 295[Model – M80] Lab India Instruments Pvt. Ltd.) to check for marginal fit of zirconia crowns to the die.[26] The accuracy range of magnification of the stereomicroscope was 7.5–60%. The stereomicroscope was used to measure each crowns P1, P2, and P3 values in mesial side of the sectioned crown. P4, P5, and P6 values were measured in distal side of the sectioned crown. In each crown, a total of six values were taken.[27]

Results

The Shapiro–Wilk test of normality shows that the three group measurements on mesial and distal follow normal distribution and parametric test was applied. The mean mesial value of zirconia coping and zirconia coping with layering and monolithic crown was 43.8 ± 11.8, 53.3 ± 8.9, and 39.4 ± 10.6, respectively. A one-way ANOVA shows that mean value of mesial among the three groups was significant ($P < 0.019$) [Figure 5]. The means value of zirconia coping with layering was significantly high when compared with monolithic crowns. Bonferroni test evidences that the difference between zirconia coping with layering and monolithic crowns in mesial was significant ($P < 0.019$). Hence, the marginal fit of monolithic crowns has better marginal fit than zirconia coping with layering.

The Shapiro–Wilk test of normality shows that the three group measurements on mesial and distal follow normal distribution and parametric test was applied [Figure 6]. The mean distal value of zirconia coping and zirconia coping with layering and monolithic crown was 42.3 ± 6.6, 55.3 ± 15.4, and 38.2 ± 6.3, respectively. A one-way ANOVA shows that mean value of distal among the three groups was significant ($P < 0.028$). Bonferroni test evidences that the difference between zirconia coping and zirconia coping with layering in distal was significant ($P < 0.028$). The means value of zirconia coping with layering was significantly high when compared with zirconia copings. Bonferroni test evidences that the difference between zirconia coping with layering and zirconia copings in distal was significant ($P < 0.028$).

A one-way ANOVA shows that mean value of distal among the three groups was significant ($P < 0.003$). Bonferroni test evidences that the difference between zirconia coping with layering and monolithic crowns in distal was significant ($P < 0.003$). The means value of zirconia coping with layering was significantly high when compared with monolithic crowns. Hence, the marginal fit of monolithic crowns has better marginal fit than zirconia coping with layering.

Discussion

The data obtained in this study showed statistically significant differences in the marginal fit of all-ceramic, zirconia copings, and zirconia coping with layering and monolithic crowns, thus supporting the research hypothesis and rejecting the null hypothesis. The marginal fit of monolithic crowns showed superior marginal fit than other two groups.

There were studies done to compare the marginal fit of metal ceramic restorations and all-ceramic restorations but very minimal studies have been done on comparison of marginal fit of all-ceramic crown fabricated using CAD/CAM technology.

In the current study, metal die with specification of 6 degree taper mesiodistally and 6 degree taper buccolingually with a circumferential shoulder of 1.0 mm and height of 5 mm was used which served the advantage of standardized preparation of the die abutment similar to a study which was conducted by Rinke *et al*. and Buchaman *et al*.

Balkaya *et al*. (2005) compared the marginal fit of full contour zirconia crowns and layered zirconia crowns were made using CAD/CAM and found that there was no statistically significant difference among the marginal fit of full zirconia crowns and layered zirconia crowns. In the current study, marginal fit of the all-ceramic crowns was fabricated with CAD/CAM technology, mesial aspect of monolithic crowns showed better marginal fit than zirconia with layering crowns. McLean and Von Fraunhofer (1971) examined more than 1000 crowns for its marginal fit and concluded that restoration would be successful if marginal gaps and cement thickness of <120 µm could be achieved. The literature showed that in the all-ceramic crowns, mean marginal discrepancy ranged from 19 µm to 160 µm. In the present study the marginal fit values are within the normal range the lowest range is 39 µm and maximum of 55 µm. All the values obtained were within the acceptable limit. Sulaiman *et al*. (1997) compared the marginal fit of In-Ceram, IPS Empress, and Procera crowns. They found that after veneering the porcelain, there was no significant change in the marginal fit of the crowns. In the current study, the marginal fit was compared between zirconia layering and monolithic crowns. The marginal fit was better in monolithic crowns than zirconia copings with layering.

Assadi *et al*. (2015) had compared the marginal fit of porcelain veneered zirconia crown and full contour zirconia crown using three different CAD/CAM systems. The marginal fit of the full contour crown showed better marginal fit than porcelain veneered zirconia crown. In this present study, marginal fit of

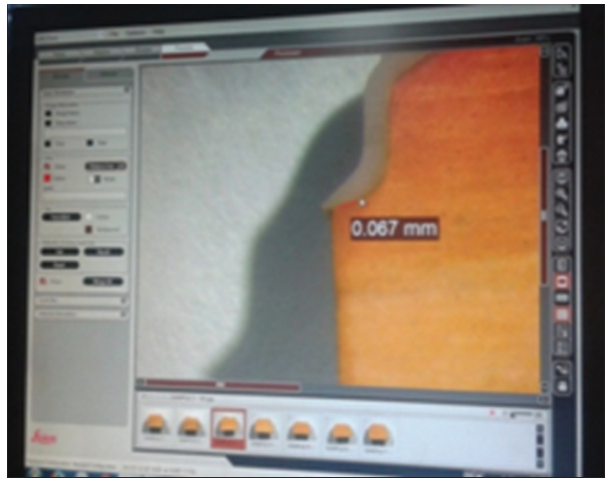

Figure 4: Sectioned crown measured for marginal fit in stereomicroscope

		Sum of Squares	Df	Mean Square	F	Sig.
MESIAL	Between Groups	1012.952	2	506.476	4.566	.020
	Within Groups	2994.768	27	110.917		
	Total	4007.720	29			
DISTAL	Between Groups	1587.462	2	793.731	7.373	.003
	Within Groups	2906.726	27	107.657		
	Total	4494.188	29			

Figure 5: One-way ANOVA table. Comparison within the groups and between the groups

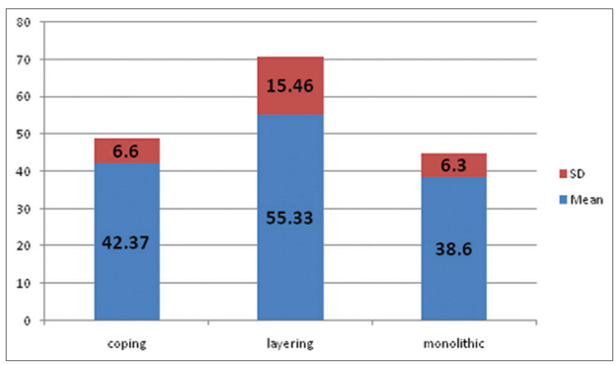

Figure 6: Comparison of marginal fit of mesial aspect of zirconia coping and zirconia coping with layering and monolithic crown

monolithic crowns showed better marginal fit than zirconia layered crowns.

Pak *et al*. (2010) compared the marginal fit of Digident and LAVA CAD/CAM zirconia ceramic crowns. All-ceramic crown prepared in central incisor, the influence of porcelain veneering after the coping fabrication was measured for marginal fit. Porcelain veneering showed that the LAVA CAD/CAM zirconia crown showed better marginal fit than the Digident crown. In the present study, significant changes were observed between the zirconia coping with layering and monolithic crowns.

Buchalla *et al*. (2000) evaluated the marginal fit of the zirconia crowns using resin cement and glass ionomer cement. Marginal fit of the crown was checked using fit checker. The marginal fit minimum of 12.34 μm and maximum of 142.81 μm each crown was investigated using a profilometer. In the current study, the crowns were luted with resin cement, the marginal fit of the crowns after sectioning was measured with stereomicroscope. Marginal fit values of distal aspect of the crowns were compared with the group III (monolithic crowns)and group II (zirconia crowns with layering).

In vitro study has advantage of providing standardized condition with respect to preparation design, technique, and experimental performance, resulting more repeatable performance.

Conclusion

Within the limitations of this *in vitro* study, the following conclusions can be drawn:

- The mean marginal fit of three groups of all-ceramic zirconia cored crowns and monolithic crowns was within the clinically acceptable range
- The full-contoured zirconia crowns showed better marginal fit than the zirconia copings with layering
- There is a marked difference between marginal fit all-ceramic crowns of zirconia with layering and monolithic crowns with the influence of firing cycles.

References

1. Holden J, Goldstein G, Hittelman EL, Clark EA. Comparison of the marginal fit of pressable ceramic to metal ceramic restorations. J Prosthodont 2009;18:645-8.
2. Abbate MF, Tjan HL, Fox WM. Comparison of the marginal fit of various ceramic crown systems. J Prosthet Dent 1989;61:527-31.
3. Rosenstiel SF, Land MF, Fujimoto J. Contemporary Fixed Prosthodontics. 3rd ed. United States: Mosby, Inc.; 2001. p. 609-70.
4. Shillingburg HT, Sather DA, Wilson EL, Cain JR, Mitchell DL, Blanco LJ, *et al*. Fundamentals of Fixed Prosthodontics. 4th ed. Chicago: Quintessence Publishing Co.; 2012. p. 291-306.
5. Coli P. Precision of a CAD/CAM technique for the production of all ceramic crowns. J Prosthet Dent 2004;17:577-80.
6. Aboushelib MN, Kleveralaan CJ, Feilza AJ. Microtensile bond strength of different components of core veneered all-ceramic restorations. Part II: Zirconia veneering ceramics. Dent Mater 2006;22:857-63.
7. Tian T, Tsoi JK, Matinlinna JP, Burrow MF. Aspects of bonding between resin luting cements and glass ceramic materials. Dent Mater 2014;30:147-62.
8. Ng J, Ruse D, Wyatt C. A comparison of the marginal fit of crowns fabricated with digital and conventional methods. J Prosthet Dent 2014;112:555-60.
9. Kelly JR. Dental ceramics: Current thinking and trends. Dent Clin North Am 2004;48:513-30.
10. Denry I, Kelly JR. State of the art of zirconia for dental applications. Dent Mater 2008;24:299-307.
11. Kwon TK, Pak HS, Yang JH, Han JS, Lee JB, Kim SH, *et al*. Comparative fracture strength analysis of Lava and Digident CAD/CAM zirconia ceramic crowns. J Adv Prosthodont 2013;5:92-7.
12. Ortorp A, Jonsson D, Mouhsen A, von Steyern PV. The fit of cobalt-chromium three-unit fixed dental prostheses fabricated with four different techniques: A comparative *in vitro* study. Dent Mater 2011;27:356-63.
13. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. J Prosthet Dent 1989;62:405-8.
14. Kelly JR, Tesk JA, Sorensen JA. Failure of all-ceramic fixed partial dentures *in vitro* and *in vivo*: Analysis and modeling. J Dent Res 1995;74:1253-8.
15. Bindl A, Mormann WH. An up to 5-year clinical evaluation of posterior In-Ceram CAD/CAM core crowns. Int J Prosthodont 2002;15:451-6.
16. Reeves WG. Restorative margin placement and periodontal health. J Prosthet Dent 1991;66:733-6.
17. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an *in vivo* technique. Br Dent J 1971;131:107-11.
18. Gonzalo E, Suarez MJ, Serrano B, Lozano JF. A comparison of the marginal vertical discrepancies of zirconium and metal ceramic posterior fixed dental prostheses before and after cementation. J Prosthet Dent 2009;102:378-84.
19. Chee WW, Donovan TE. Polyvinyl siloxane impression materials: A review of properties and techniques. J Prosthet Dent 1992;68:728-32.
20. Rinke S, Huls A, Jahn L. Marginal accuracy and fracture strength of conventional and copy-milled all-ceramic crowns. Int J Prosthodont 1995;8:303-10.
21. Suleiman SH, von Steyern PV. Fracture strength of porcelain fused to metal crowns made of cast, milled or laser-sintered cobalt-chromium. Acta Odontol Scand 2013;71:1280-9.
22. Beschnidt SM, Strub JR. Evaluation of the marginal accuracy of different all-ceramic crown systems after simulation in the artificial mouth. J Oral Rehabil 1999;26:582-93.
23. Suarez MJ, Gonzalez de Villaumbrosia P, Pradies G, Lozano JF. Comparison of the marginal fit of Procera All Ceram crowns with two finish lines. Int J Prosthodont 2003;16:229-32.
24. Korkut L, Cotert HS, Kurtulmus H. Marginal, internal fit and micro leakage of zirconia infrastructures: An *in vitro* study. Oper Dent 2011;36:72-9.
25. Choi YS, Han JS, Yeo IS. *In vitro* evaluation of fracture strength of zirconia restoration veneered with various ceramic materials. J Adv Prosthodont 2012;4:162-9.

26. Gu XH, Kern M. Marginal discrepancies and leakage of all-ceramic crowns: Influence of luting agents and aging conditions. Int J Prosthodont 2003;16:109-16.
27. Wolfart S, Wegner SM, Al-Halabi A, Kern M. Clinical evaluation of marginal fit of a new experimental all-ceramic system before and after cementation. Int J Prosthodont 2003;16:587-92.

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