J. Basic. Appl. Sci. Res., 3(9)222-227, 2013
© 2013, TextRoad Publication

ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Comparison of Fracture-Toughness of Ziconia-Fabricated Copings which is Generated in two Methods: CAD/CAM & Copy Milling Methods

Abdolhamid Alhavaz[1], Ladan Jamshidy*[2], Mohammad Ali Bagheri[3], Mojtaba Ramezani[4], Masoume Ahangar Darabi[5]

[1]Assistant Professor Department of Prosthodontics, Faculty of Dentistry, Babol University of Medical Sciences-Babol-Iran
[*2] Assistant Professor Department of Prosthodontics, Faculty of Dentistry, Babol University of Medical Sciences- Babol-Iran
[3,4] Assistant Professor Department of Prosthodontics, Faculty of Dentistry, Babol University of Medical Sciences-Babol-Iran
[5] Masoume Ahangar Darabi, Translator, BA: Bachelor of Arts

ABSTRACT

The purpose of this study was to investigate of fracture-toughness of zirconia-fabricated copings which is generated in two methods: CAD/CAM and Copy Milling. In this invitro study 40 Epoxy resin (shoots dental, Germany) dies which were duplicated of one mandibular Molar model (with standard preparation) by 40 poly-viniyl-siloxane impressions were made. This dies were subdivided into two groups of 20 dies, so that on one of these two groups CAD/CAM-fabricated (CERCON, Degudent Germany) copings (10 of them were cemented with zinc phosphate (aria dent, iran) cement and 10 other were cemented with panavia F2(Kuraray, japan) cement) were inserted and on another one copings fabricated by copy milling (dentium, korea) method (10 of them were cemented with panavia F2 and 10 other were cemented with zinc phosphate) were inserted. The specimens were stored in distilled water at 37 C for 1 week and fracture strength test was performed in a universal testing machine (crosshead speed: 1 mm/min). There were no significant difference in fracture strength between CAD/CAM fabricated copings cemented with panavia F2 (1694.63 N) and zinc phosphate cement (1555.62 N, P=0.462), and also there were no significant difference in fracture strength between copy milling fabricated copings cemented with panavia F2 (1492.54 N) and zinc phosphate cement (1430.44 N, P=0.747). Two kinds of copings (generated with CAD/CAM and copy milling method) were able to resist of occlusal forces but CAD/CAM fabricated copings are prefer because of it's advantages.
KEY WORDS: Coping, Zirconia, CAD/CAM, Copy milling, Panavia, Zinc phosphate .

INTRODUCTION

Nowadays, dental studies, in order to obtain the optimal esthetic in fixed restorations, have been directed towards the metal-free restorations. Colore of the soft tissue adjacent to metal-free restorations, in comparing with the soft tissue adjacent to the Porcelain Fused to Metal (PFM) restorations, seems very natural. Many ceramics such as Spinel, Alumina, and Lithium Disilicate reinforced Ceramic were proposed to fabricate the metal-free restorations. These materials have a special and less indication to fabricate fixed Partial Denture (FPD) (1).

Zirconia has been recently introduced as an acceptable structure in fabricating metal-free cores. From 1998 up to now, in tens of studies, %90 or more successes have been reported for Zirconia-based prostheses. A 0.5mm-thickness Zirconia is used for fabricating frame work of 3-5 units–fixed prostheses (2, 3). Yttrium Oxide (%3mol of $Y2O3$), is added to pure Zirconia in order to stabilize its Tetragonal state at room temperature. This Zirconia has a high initial flexural strength and fracture-toughness (4, 5). Yttrium Oxide Partially Stabilized Zirconia (Y-TZP) has proper mechanical specifications which makes it suitable for use to dental restorations. Of these specifications can mention the dimensional and chemical stability, high mechanical strength and fracture-toughness. Zirconia cores, like as metal, are Radio opac that makes it easy to distinguish marginal integrity and recurrent caries in radiographic images (5, 6). Zirconia is also used to fabricate fixed restorations supported by a tooth or implant. Bridge or crown restorations can be fabricated in respect of the reliable characteristics of this material. Due to metal-free characteristic of Zirconia, the finishing line at the level of gingiva can be used for obtaining the optimal esthetic results. Some physical characteristics of Zirconia also must be considered to obtain optimal esthetic. In fact, the color of Zirconia is not the same as tooth and it is opac, that of course it is considered as an advantage for covering discolored tooth or metal posts used in tooth. In contrast, if the translucency is needed, another ceramics such as Alumina or Lithium Disilicate can be used (1, 5, 7). Mean force in chewing has been reported 110-150 N. its maximum amount at incisor teeth is 200 N, at molars is 350 N and in patients with parafunctional habits, it rises up to 1200N (8). So the fixed restorations in posterior region must be able to bear this rate of force. By assessing the mechanical characteristics of in vitro ceramics fabricated coping, the rate of their flexural strength and fracture-toughness is determined. The strength which is required to fracture or plastic deformation is defined as an ultimate stress and is influenced by factors such as size of cracks and defects available on the surface of materials (9). Using CAD/CAM system is a current method to fabricate Zirconia cores. For years after years, CAD/CAM technology is used in dentistry. Nowadays, this

[*]**Corresponding Author:** Ladan Jamshidy, Assistant Department of Prosthodontics, Faculty of Dentistry, Babol University of Medical Sciences - Babol-E-mail address: ladanjamshidy@yahoo.com.

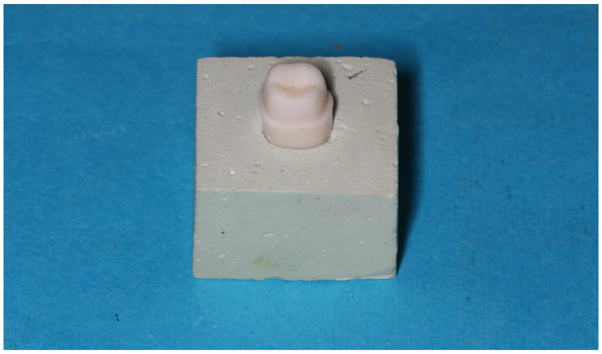
technology is used in dentistry to aid the dentists and laboratory technicians for fabricating dental restorations such as inlay, onlay, cores and bridges in accurate gauges and forms. Another advantage of this technology is that, in some cases, the number of sessions to fabricate restorations can be reduced to one session. Of the other advantages proposed for CAD/CAM system can mention the automating of processes and removing the human errors, marginal accuracy, very low amount of porosity in coping ceramics and lessening the possibility of cracking, no needing to impression (in some systems) and eliminating the time spent to do that, making an one-session appointment with the patient (in cerec system), a good reception of the patient, a variety in selecting type of ceramic for coping based on the rate of required strength, and translucency (10). The disadvantages in using CAD/CAM system consist of needing expensive equipment and technical sensitivity for imaging the prepared tooth surface (11). A current and conventional way to fabricate coping is copy milling technique that, its principles are similar to those applied in duplicating house keys.

Advantages of copy milling technique are cheapness of both system and copings produced by it to those produced by the CAD/CAM technique, and of course with respect to the economical aspects, it is considered as a main factor. The simplicity use of copy milling system, in comparison with complicated software in CAD/CAM technology, also enables it to be common system for laboratory applications (12, 13).

Zirconia mechanical characteristics can significantly be hazarded by current clinical and laboratory methods. It has been shown that some surface treatments especially airborne particle abrasion, heat treatment, sand blasting, grinding, weaken copings significantly and also produce surface defects which cause a considerable reduction in strength (14, 15, 16, 17). Surface defects act as stress concentration regions, and although, they originally are microscopic in size, potentially begin crack and then expand progressively (14, 15, 18). (On these bases, in this study, two methods were proposed for ceramics preparation so that defect results from these two methods on surfaces would be considered on Zirconia fracture-toughness). Regarding to the results of some studies, resin cements , increase significantly ceramics fracture-toughness by filling the surface small defects produced by acid etching, air abrasion (19). So in this study, the effect of the resin cement on the fracture-toughness is also assessed by using two different types of cement; Zinc phosphate and Panavia F2.

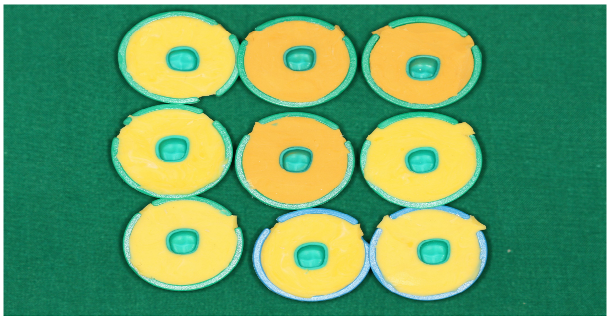
MATERIALS AND METHODS

In this invitro study a standard preparation on mandibular molar model with this charachtristic was performed (W&H turbine, Allegra): 1.5mm occlusal reduction, 1 mm axial reduction with 6-8 convergency (3-4 for each side)(5). Round shoulder finishing line with at least 1mm width was prepared on lingual and facial surfaces in two planes (5,20), and all of line angles were rounded to reduce stress concentrations (figure 1).



Prepared model served as a master die for preparation of 40 other dies with the use of a highly filled epoxy resin(shoots dental Germany) of similar elastic modulus as human dentin(12/9 Gpas).

For this purpose 40 impressions were taken with Poly Vinil Siloxane panacil (kettenbach, Germany) from prepared model, (figure 2).



Then these impressions were poured with epoxy resin under vacum to reproduce void free dies. Radiographic images (Eastman Kodak, America) were prepared to ensure void free dies (5). These dies were subdivided to two groups (n=20). In the first group copings were manufactured on epoxy replicas by CERCON CAD/CAM machine (n=20) and in the other copy milling machine was used (n=20). Each of dies in group one was scanned and data transformed to CAD data. Then blanks of Zirconia ceramic (yttrium oxide tetragonal) were milled by expert machine to produce coping with 1mm thickness. It shall be remembered that in this software, 30 virtual thickness was intended under each coping(cement space). Then copings were sintered in porcelain furnace in 1350 for 7 hours and 30 minutes. The dies of groups were covered with two layers of spacer (vita inceram interspace varnish) with resultant thickness of 30. Care must be taken that the varnish is 0.5mm short of finish line (20). After each application f varnish 5 min is required for drying and after the second, 20 min time is required. Then autopolymerizing acrylic resin (rain bow, dentium) was used to construct acrylic resin copings. Thickness was assessed in different areas by Iwansongauge (center of buccal, lingual, mesial, distal). Reduction was performed in thick areas until optimum thickness of 1 mm was attained. Then the patterns were put on the dies and were read by a sensor guided by the technician, and the copings were concurrently milled out of a partially sintered zirconia blanks. Copings were then sintered in the furnace. To ensure fully seated copings on the dies, fit checker (anti-spray, boush) was used on the intaglio surface of copings and if any pressure points detected, the respective coping was excluded from study and a new one was made.

10 dies of the CAD/CAM group and 10 dies of the copy milling group were selected. The copings were cemented by Panavia F2 cement (by Kuraray Company, Japan, according to the manufacturer). An air sealing gel, according to the manufacturer, was used on the finishing line of copings.

Another 20 dies (10 of the CAD/CAM group and 10 of the copy milling group), according to the manufacturer, were cemented by Zinc Phosphate cement (by the Arial Dent Company). Copings, in the same first way, were placed by a finger-pressing on their related dies and then, the extra cement was removed. After that, in order to ensure copings fully seated, all crowns were placed by a 20N-static force for 5min. (5).

Measures of each crown, from the occlusal surface of coping to the apical surface of model, before and after cementation were gauged by a caliper to confirm fully seated crowns. none of them shouldn't have an increase in vertical dimention more than 50 µm.(5)

In the next stage, in order to imitate the hydrolytic effect of saliva on ceramic and cement (static fatigue), cemented copings were maintained in 37˚c Normal Saline for 1 week (5, 21, 22).

In this manner, crowns were rested by Universal Testing Machine, (by Zwick/Roell Company, Germany). A 1 mm/min force was applied on each of copings by using of hardened steel balls with 3mm thickness (5, 13, 23).

The amount of this force was recorded by machine, and then mean fracturing force of groups was compared and assessed. The resulted information was analyzed by T-test.

RESULTS

For data analyzing, first based on Kolmogorov-Smirnov Test, it was specified that data distributing of groups is normal. After doing the test and data analyzing, the mean required force to fracture copings fabricated by CAD/CAM group and cemented with Panavia cement, was 1694.36 N and that for those cemented with Zinc Phosphate, was 1555.62 N, so that there was no significant difference between these two groups (P=%462).

In copy milling group, required force to fracture copings which cemented with Panavia cement, was 1492.54 N and that also for those cemented with Zinc Phosphate, was 1430.44 N and again there was no significant difference between two groups (P=%747), table 1,2,3 and figure 3.

Method	Cement	Number	Mean Force	Standard deviation	Mean Standard Error	P-value
CAD/CAM	Panavia	10	1694.63	426.97	135.02	%462
	ZP	10	1555.62	398.799	126.111	
Copy-milling	Panavia	10	1492.54	353.087	111.656	%747
	ZP	10	1430.44	484.291	153.146	

Table 1. mean force required to fracture copings fabricated in CAD/CAM and Copy Milling methods and cemented by Panavia and Zinc Phosphate (ZP) cements.

Method	Number	Mean Force	Standard deviation	Mean Standard Error	P-value
CAD/CAM	20	1625.13	408.38	91.317	P=%216
Copy-milling	20	1461.49	413.722	92.511	

Table 2. mean force required to fracture copings fabricated in CAD/CAM and Copy Milling methods.

Cement	Number	Mean Force	Standard deviation	Mean Standard Error	P-value
Panavia	20	1593.58	395.166	88.362	P=%45
ZP	20	1493.03	436.527	97.61	

Table 3. mean force required to fracture copings cemented by Panavia and Zinc Phosphate (ZP) cements.

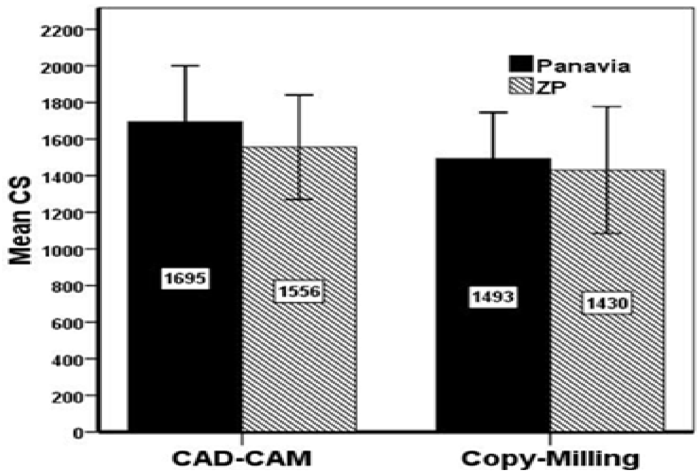


Figure 3. mean force required to fracture copings fabricated in CAD/CAM and Copy Milling methods and cemented by Panavia and Zinc Phosphate (ZP) cements.

DISCUSSION

As mentioned before, there was no significant difference between 4 groups of copings cemented and fabricated in two different methods. So the null hypothesis, in which Zirconia fracture-toughness is not influenced by types of cement and coping-fabricating techniques, was accepted. There are several variables that can be effective on the amount of fracture-toughness of materials applied in ceramic copings. These variables including coping thickness, type of cement, fabricating technique, way of finishing and polishing the core surface, temperature of sintering and its veneering material, type of finishing line, direction and type of applied force and test condition (e.g. maintenance conditions, process and type of test)(21,22).

Thickness of zirconia copings is very important and a few changes in it can influence its fracture-strength (21).

In this study, epoxy resin dies were used instead of natural teeth that since these 40 impressions were prepared by just one dental model and then dies were poured by epoxy resin, all reduction parameters such as walls convergences and finishing line were controlled and the same size of these epoxy dies and subsequently fabricated copings were resulted from them. So in this study, it was tried to compare and assess two variables, type of cement and fabricating technique, and others were controlled to be the same as before. There is a positive point in use of these epoxy dies, as they are mechanically similar to the tooth(modulus of elasticity). Moreover, since epoxy dies form a proper micro-roughness surface for bonding by acid phosphoric %34, they can provide a layer similar to natural tooth for using adhesive cements (5), so cement adhesion was assessed as effective factor. In order to identically distribute stress in this test, location of force applied on copings was all the same and was in central fossa. The amount of required force to fracture Zirconia-fabricated copings in this study, is almost near to other done studies.

Saeed Salehi et al., 1390/2012, Shiraz University, in a study on the fracture-toughness of Zirconia cores fabricated in two methods, CAD/CAM and Slip casting, calculated this rate for CAD/CAM-fabricated copings: 1411±424 N and for Slip casting-fabricated copings: 1542±412 N.

Sven Reich et al., in a study, mentioned this rate between 980-1400N for molar or pre-molar copings (2).

Beuer et al., 2009, reported that the amount of fracture-load in veneered-porcelain crowns which were formed automatically by CAD/CAM system and sintered to the base of Zirconia, is more than those in Zirconia-based conventional veneer crowns and the crowns in which veneer-porcelain was pressed to the Zirconia coping (24).

Nina Beck et al., 2010, compared the fracture-resistance of Copy Milling-fabricated Zirconia ceramic posts with that of pre-fabricated Zirconia posts and concluded that fracture-strength of pre-fabricated Zirconia posts with resin composite core (267N) is significantly more than those of Copy Milling-fabricated Zirconia posts with resin composite core (139N) (25).

In Bindle et al. study in which copings were placed on composites-fabricated dies, the amount of fracture-toughness for 0.4mm-thickness copings was obtained 697-1607N (2) which is almost near to those resulted in this study. And of course in Bindle's study, the purpose was only determining fracture-toughness rate of Zirconia copings. In human, mean swallowing and chewing force is 40 N and maximum chewing force at posterior teeth varies 200 to 540 N (26).

In another study, mentioned that dental restorations are under forces of 60-250N during functioning and even 500-800N in a short period of the time. However, it varies based on location: in molars: 400-890N, in pre-molars: 222-445N, in canines: 133-334N and in incisors: 89-111N (8).

In this in vitro study, both Zirconia coping groups fabricated in CAD/CAM and Copy Milling methods were able to bear forces much more than maximum force applies in chewing. Copings were not veneered because the strength of crown is mostly obtained by the strength of its coping (26). So in order to fabricate all ceramic crown, both these systems are able to resist the chewing maximum forces applied in the mouth.

Different opinions have been stated in literature with regard to use adhesive and/or non-adhesive (conventional) cements. Bindle et al. stated that ceramic crowns which use adhesive cements, to those use non-adhesive one, apply the forces more directly on their below tooth structure. In the mouth, adhesive cements prevent salvia penetration to intaglio ceramic crowns and therefore, they also prevent the salvia weakening effect on crown's strength (27).

In another study, Martin Rosentritt et al. stated that there was no significant difference in the fracture-resistance due to use adhesive or conventional cements (28).

In this study, although, the amount of the required force to fracture copings cemented by Panavia cements was more than those cemented by Zinc Phosphate in both methods, but this difference was not statistically significant, so it is proposed to cement the copings by either types of cement; adhesive or conventional cement.

The limitation of this study was that fatigue process was not considered. Tooth crowns are almost nearly loaded to 1500 cycles and the amount of force applied on it, is raised up to 700N or more, and also during 5years, this rate is reached nearly 2milions cycles. In copings fabricated with these two methods examined in this study, at the beginning of functioning, there may be no significant difference in their strength, but cannot say that some years after functioning in the mouth, again the rate of their fracture-resistance be equal.

One of another limitations is that, it was an in vitro study in which copings were influenced by single-direction forces and were not conditioned by multi-direction forces in oral cavity.

CONCLUSION

Findings of this study revealed that two different fabricating methods (CAD/CAM & Copy Milling) cannot make difference in ultimate strength and fracture-resistance of Zirconia cores, and therefore it cannot be said that one of these two methods is better than the other one. Moreover, the type of cement also has no effect on ultimate strength. Regarding to CAD/CAM mentioned advantages, in authors' opinion, it is preferred to use this system. Meanwhile, in these two fabricating methods, the required force to fracture cores is more than those applied in the mouth.

REFERENCES

[1]. Manicone PF, Rossi Iommetti P, Raffaelli L. An overview of zirconia ceramics: basic properties and clinical applications. J Dent 2007; 35: 819-826 .

[2]. Reich S, Petschelt A, Lohbauer U. The effect of finish line preparation and layer thickness on the failure load and fractography of ZrO2 copings. J Prosthet Dent 2008; 99: 369-376 .

[3]. Sollazzo V, Pezzetti F, Scarano A, Piattelli A, Bignozzi CA, et al. Zirconium oxide coating improves implant osseointegration in vivo. Dent Mater 2008; 24: 357-361 .

[4]. Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendations: a systematic review .J Prosthet Dent 2007; 98: 389-404 .

[5]. Zahran M, El-Mowafy O, Tam L, Watson PA, Finer Y. Fracture strength and fatigue resistance of all-ceramic molar crowns manufactured with CAD/CAM technology. J Prosthodont 2008; 17: 370-377 .

[6]. Raigrodski AJ. Contemporary all-ceramic fixed partial dentures: a review. Dent Clin North Am 2004; 48: 531-544 .

[7]. White SN, Miklus VG, McLaren EA, Lang LA, Caputo AA. Flexural strength of a layered zirconia and porcelain dental all-ceramic system. J Prosthet Dent 2005; 94: 125-131 .

[8]. Yilmaz H, Aydin C, Gul BE. Flexural strength and fracture toughness of dental core ceramics. J Prosthet Dent 2007; 98: 120-128

[9]. Guazzato M, Albakry M, Vincent swain M, Ironsidej. Mechanical properties of in-ceram alumina and in-ceram zirconia.2002;15(4):339-45.

[10]. Anusavice KJ. Phillips' Science of Dental materials. In: Anusavice KJ. Dental ceramics. 3nd ed., New York: W.B.Saunders Company; 2003. p. 655-717 .

[11]. Davidowitz G, Kotick Ph. The use of CAD/CAM in dentistry. Dent clinic,2011;55:559-570.

[12]. Karl M, Greaf F, Wichmann M, Krafft T. Passivity of fit of CAD/CAM and copy-milled frameworks,veneered frameworks,and anatomically contoured,zirconia ceramic implant-supported fixed prostheses. J of prosthetic dentistry,2012;107:232-238.

[13]. Beck N, Graft F, Wichman M.in vitro fracture resistance of copy-milled zirconia ceramic posts. J of prosthet dent,2010;103:40-4.

[14]. Wang H, Aboushelib M, Feilzer A. Strength influencing variables on CAD/CAM zirconia frameworks. Dental materials,2008,24,633-638.

[15]. Beuer F, Aggstaller H, Edelhoff D, Gernet W, Sorensen J. Marginal and internal fits of fixed dental prostheses zirconia retainers. Dental material,2009,25:94-102.

[16]. T Vagkopoulou ,SO Koutayas , P Koidis , JR Strub, Zirconia in dentistry:part 1 discovering the nature of an upcoming bioceramic, Eur J Esthet Dent 2009 summer;4(2):130-51.http//www.ncbi.gov/pubmed

[17]. Chai J, Chong K. Probability of failure of machined zirconia dental ceramic core materials. J prosthodont2009;22:340-341

[18]. Venkatesh R. The effects of heat treatment and coating roughness on the strength of alumina-zirconia fibers. Composites science and technology.2002;62:205-212.

[19]. Qeblawi D M, Munoz C A, Brewer J D, Monaco E A. The effect of zirconia surface treatment on flexural strength and shear bond strength to a resin cement. J of prosthetic dentistry,2010;103(4):210-220.

[20]. Kianoush Torabi, blacksmith Ahmed Hassan, Saeed Salehi, Motamedi Milad, Comparison of fracture resistance Cores made of Zirconia By two methods: SLIP CASTING & CAD/CAM, Shiraz University of Medical Sciences, Thesis Specialty, 1390, The Fourth Period, number 4.

[21]. Snyder MD, Hogg KD, Load to fracture value of different all-ceramic crown systems. J Contemp dent pract.2005;4:54-63.

[22]. Liang Fa Hu, Wang Ch. Effect of sintering temperature on compressive strength of porous yttria- stsbilized zirconia ceramic. Ceramic international,2010,36:1697-1701.

[23]. Tsalouchou E, Cattel MJ, Knowles JC. Fatigue and fracture properties of yttria partially stabilized zirconia crown systems. Dent Mater,2008;24:308-318.

[24]. Beuer H, Schweiger J, Eichberger M. A new fabrication mode for all-ceramic restorations. DentMater,2008;25:121-128.

[25]. Monaco E, Kim S, kim H, Brewer J, Comparision of fracture resistance of pressable metal ceramic custom implant with CAD/CAM commercially fabricated zirconia implant abutments, journal of prosthetic dentistry, 2009,4:226-230.

[26]. Attia A, Kern M, Influences of cycle loading in luting agents on the fracture load of two all-ceramic crown system. J Prosthet Dent,2004;92:551-556.

[27]. Bindle A, Luthy H, Mormann WH. Thin wall ceramic CAD/CAM crown copings: strength and fracture pattern. J or rehab,2006;33:520-528

[28]. Rosentritt M, Behr M, Thaller Ch, Rudolph H, Feilzer A. Fracture performance of computer-aided manufactured zirconia and alloy crowns. Quintessence int ,2009;40:655-662.