ISSN:1812–1217

Evaluation of Internal Adaptability of Different Core Materials (an in Vitro Study).

Qasim Abdul-Kareem
BDS,MSc (Lect.)
Department of Conservative Dentistry
College of Dentistry, University of Mosul

Rita R. Robeil
BDS, MSc (Asst.Lect.)
Department of Conservative Dentistry
College of Dentistry, University of Mosul

Maha M. Yahya
BDS,MSc (Lect.)
Department of Conservative Dentistry
College of Dentistry, University of Mosul

الخلاصة

الأهداف:الهدف من هذه الدراسة المختبرية هو المقارنة بين مقدار الفراغ الداخلي للتيجان المصنعة من مواد مختلفة. **المواد وطرائق العمل** : تم تحضير المثال البلاستيكي للسن الرابع الاعلى للتغطية التامة بقياس 1 ملم للكتف المدور عند الحافة و 2-5 درجات، لتدرج السطح المحوري ثم تم نسخ هذا السن الى مثال معدني وتحضير خمسة عشر مثال من مادة الجبس البلاستيكي وتقسيمها الى ثلاث مجاميع لتحضير التيجان من مواد مختلفة (النيكل كروم، امبريس والزركون). اجري قياس قيمة الاطباق الداخلي بواسطة مادة السيليكون الابيض والاسود بطريقة نسخ الفراغ الداخلي ثم قص هذه النسخة السيليكونية بقاطع جراحي طوليا الى جهتين الانسي الوحشي والوجهي اللساني وقياس سمك الطبقة السوداء عند اربع نقاط (الحافة ، الكتف المدور، السطح المحوري، والطاحن) باستعمال المجهر الرقمي ثلاثي الابعاد بقوة تكبير (40).تم حساب المعدل ومقارنته احصائيا . **النتائج** : اظهرت النتائج وجود فرق معنوي في التكيف الداخلي للمواد الاساسية،والتغطيات المصنعة من مادة الزركونيوم والتي اظهرت اطباقا وتكيفا داخليا اعلى . **الاستنتاجات**: ان التغطيات الاساسية المصنعة من مادة الزركونيوم ذات تكيف داخلي واطباق اعلى من مادتي الامبرس سيرام والنيكل كروم.

ABSTRACT

Aims: The aim of This study was to compare the marginal and internal adaptation of cores which are fabricated of different materials and systems. **Methods**: In this experimental study, one Ivorine maxillary right first premolar (A -3 Z; Frasaco, Tettnang, Germany) was prepared for full coverage of zirconium,Nickle chromium and ceramic cores. The tooth was prepared with 1 mm rounded shoulder and 2-5 degrees tapering. Nickle chromium die was prepared for full coverage of upper first premolar, and duplicated to produce fifteen resin stone dies.The specimens were devided in to three groups (n=5). Cores were fabricated using NiCr, Empress ceramic, manual Zirconia frame works respectively. Internal space replica technique was used to evaluate the marginal and internal adaptation of the cores using Fit and Bite checker silicone material. The resulted replica of each core was sectioned and the thickness of the black and white silicone layer was measured at marginal and internal points.Data was calculated and compared statistically using Kruskal_Wallis test at $p<0.05$. **Results**: There was a significant difference in the internal adaptation of different core materials . Copings fabricated of zirconia material have shown minimum thickness and higher internal adaptability. **Conclusions**: Zirconia copings have superior marginal adaptability when compared to NiCr and Empress Ceram materials.

Key words: Marginal fit,NiCr, Empress ceram, zirconia core.

Abdul-Kareem Q,Robeil RR, Yahya MM, Evaluation of Internal Adaptability of Different Core Materials(an in Vitro Study). *Al–Rafidain Dent J*. 2014; 14(2):272-278.

Received: 28/4/2013 ***Sent to Referees:*** 28/4/2013 ***Accepted for Publication:*** 30/6/2013

INTRODUCTION

Esthetically oriented modern dentistry frequently utilizes high strength, biocompatible all-ceramic materials to satisfy the clinical demand of a patient. These materials have to meet with three important criteria like high fracture resistance, aesthetics and marginal fit for long-term survival in complex oral environment.(1) The marginal fit of the all-ceramic systems can be a critical factor to its long-term success. Inaccurate marginal adaptation is potentially detrimental to the tooth and the supporting periodontal structures. (2, 3)

Marginal and internal fit is an

important characteristic that can contribute to clinical performance.[4,5] Numerous studies have evaluated the marginal and internal adaptation of single-tooth crown restorations fabricated from various system and materials.[6,7]

Different methods were used to determine the fit of a restoration, which made it difficult to compare the various studies. Holmes et al., (1989) who established a uniform terminology including marginal gap, absolute marginal gap, vertical marginal gap, horizontal marginal gap, as well as over- and under-extension.[8]

Several materials are currently used to improve the fit of crowns by detecting interferences on their internal surfaces prior to cementation, consequently enhancing retention and marginal integrity.

Among those materials are silicones, disclosing waxes, rouge dissolved in chloroform, and spray powders.[9] The selected material is placed inside the casting, which is then seated on the prepared tooth and subjected to normal cementation pressure. After removal of the casting, the fit-indicating material remains on the intaglio surface, revealing potential areas of misfit. The areas detected to interfere with proper seating of the casting may be selectively removed to achieve complete seating of the restoration. [10]

In an attempts to improve the strength and fracture toughness of dental prostheses, several new ceramic materials and techniques have been developed during the last decades. All-ceramic fixed dental prostheses (FDP) frameworks can be made from various high-strength ceramic materials .Yttria-stabilized zirconia has proven clinical suitability for posterior FDP.[11]

The purpose of this study was to compare the marginal and internal adaptation of cores which were fabricated using NiCr, Empress ceramic and manual Zirconia frame works using fitness indicating material that are(Bite Checker black silicone and Fit Checker White silicone). The white silicone was used just to support the black silicone layer.

MATERIALS AND METHODS

In this experimental study, one Ivorine maxillary right first premolar (A -3 Z; Frasaco, Tettnang, Germany) was prepared for full coverage of zirconium crowns, the tooth was prepared with 1 mm rounded shoulder and 2-5 degrees tapering to be suitable for restoration with the different experimental materials.

Duplication of the Prepared Tooth :

A stainless steel stick was attached to the prepared tooth which prevent its tilting to sides while impression taking. An impression was taken to the prepared tooth using Vinylpolysiloxane addition silicone (Virtual) duplicating material (Ivoclar-vivadent, Germany) by using custom made cylinder shape impression tray. Aspoon which is supplied with the impresion material was used to have equal amounts of base (blue) and catalyst (white), the proper mixture should have no streaks but have a homogenous color. After 2-4 min the impression had set. The resulted impression was filled with wax (Kronenwachs ,Bego,Germany), then cast into metal model using Nickel Chromium (NiCr) dental alloy (Niadur DFS, Germany).

Duplication of Metal Specimen:

The metal specimen was duplicated fifteen times using vinylpolysiloxane addition silicon (elite double 8 , ZermackSpA, Rovigo- Italy) shown in Figure (1), the resulted moulds were filled with resin stone material shown in Figure (2). The powder and liquid were mixed according to the manufacturer instructions to obtain fifteen stone dies as shown in Figure (3). The specimens were divided in to three groups, each group consists of five stone dies.

Three different materials were used to fabricate the copings, NiCr (Niadur DFS, Germany), IPS e.maxceram (ivoclarvivadent) and Zirconia (Zirkonzahn, Italy), for manual milling system.

Figure (1): Elite double 8, Zermack impression material.

Figure 92): Picodent resin stone.

Figure (3): NiCr die with resin stone dies.

Core Fabrication:

1. Group 1 : NiCr cores: A sprue former of 1.7mm diameter (14 gauge) was attached. The wax pattern was placed at about 6 mm distance from the open end of the ring, and then lubricated. The investment material (BellavestR SH, Bego, Germany) was mixed according to the manufacturer instruction, a brush was then used to apply investment material gently to the wax sample, then the remaining investment was poured into the ring carefully to avoid air entrapping. After the casting has been filled with investment material. The ring was then placed into an oven (Detroter,Q.D., manufacturing co., ltd, England). A centrifugal casting machine (Lucas senior, signer engineer manufacturer, England) was used for casting. After casting has been completed,. A regular sand blast, aluminum oxide 250µ (Al_2O_3, Glanz Degussa, Germany), was used to clean the cast sample using sand blasting unit (SBU 1.0, Germany), after cleaning the cast model, the sprue was cut and separated from the sample by using a separating disc. The copings were then finished using finer abrasive stone burs. Then a rubber points and small carbides used for selective finishing of the core morphology.

2. **Group 2**: Ceramic cores: Cores are fabricated using e-max (IPS empress, ivoclarvivadent, ceramic material, wax pattern was done and sprue attached to about 5 mm distant to the ring and invested. Vario press 300 (zubler, Germany) furnace was used to fabricate the e- max cores according to the manufacturer's instructions.

3.**Group 3**: Zirconia cores: PresinteredYittria stabilized zirconia blanks were used to fabricate cores by manual milling procedure, the cores obtained to the final size and did not need for further sintering.

Measurements of the internal and marginal adaptation:

The cement space replica technique was used to evaluate the internal and marginal adaptation of the cores, using high flow black silicone (Bite checker) and white silicone (Fit checker) from (GC.corp.Tokyo. Japan). Bite checker (Black silicone) was mixed according to the manufacturer instructions and applied to the inner surface of the core. Core was adapted to the master die ,then held with finger pressure for 5 minutes, after material had set, the core was carefully removed from the master die. The white silicone (fitchecker) was mixed and gently applied to the core over the black silicone layer, the core was then adapted to the master die and held with finger pressure for 5 minutes, in which the two materials had bonded firmly together, the white silicone layer was used just for supporting the black silicone layer. The core was then carefully removed and the silicone replica was separated gently from the core to avoid tearing of the material. The replica was then sectioned using a surgical blade (W.R.swann and co. LTD. England), bucco-lingually and mesio-distally, care was exercised to obtain equal sections. The section was examined under the stereo microscope. Motic digital stereo zoom microscope (Motic Incorporation LTD. Hong Kong), at 40 X. The silicone layers were examined and measurements were taken of the perpendicular distance from the replica site opposing to the internal surface of the restoration to the die at sixteen different points of the bucco-lingual and mesio-distal sections, The whole twenty samples were examined in the same way. All the measurements were obtained by one operator, and the reference point for measuring the marginal gap was obtained as described by Holmes et al., (1989). [8] All the measured data obtained from the bucco-lingual and mesio- were able distal sections were averaged as the data of four locations margin (M), rounded shoulder (RS), axial wall (A) and occlusal area(O). [12]

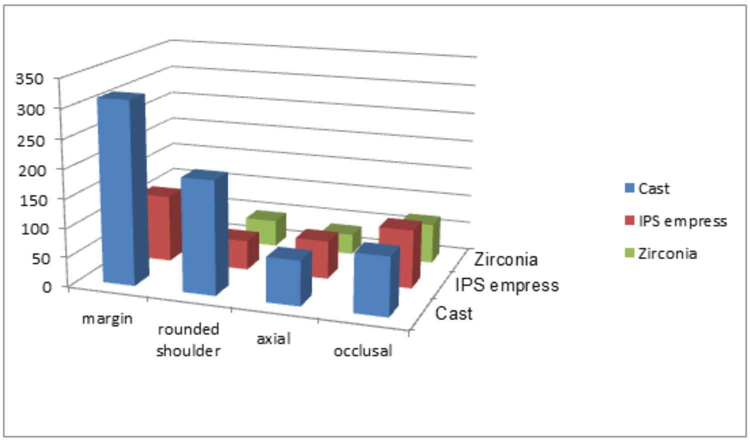
RESULTS

Kruskal_Wallis test was used to analyze the data of this study. The means of the thickness in micrometers (μm) of marginal and internal adaptation of the three groups was taken as the mean of the four points (marginal, rounded shoulder, axial and occlusal) of the bucco-lingual and mesio-distal sections of the silicone replicas of the three groups, and listed in Table (1) and illustrated as histogram in Figure (4). The results of this study showed that there was a significant difference in the internal adaptation of different core materials ($p<0.05$) . Copings fabricated using zirconia material have shown minimum mean and higher internal adaptability.

Table (1): Internal adaptation of experimental materials
(zirconia shows less value of internal gaps).

Mean Ranks	Cast	IPS Empress	Zirconia	Dt.	Sig.
Cast	10	6.25	3.25	4.997	*Zirconia group
IPS Empress		3.75	6.75		
Zirconia			3		

*significant difference at p<0.05.



Figure(4) :Bar chart of the means of the three groups.

Table(2): Kruskal-Wallis testshowsa significant differencebetweenthegroups.

	Cast		IPS empress		Zirconia	
	Degrees	**Ranks**	**Degrees**	**Ranks**	**Degrees**	**Ranks**
Margin	314	12	115.6	9	59.78	4
Rounded shoulder	194	10	50.66	3	46.38	2
Axial	76.34	7	65.54	5	35.3	1
occlusal	281	11	99.64	8	68.3	6
∑		40		25		13
C.F.	1					
Kc.	7.038					
Kt.	5.99 (0.05) (2)					
Dec.	***significant at p<0.05**					

DISCUSSION

Marginal adaptation is essential in increasing the long-term success of a restoration.[13] Increased marginal discrepancy causes maladjusted restorations and results in a high risk of periodontal diseases and tooth decay . For full ceramic crowns, a marginal gap between 1 and 165 µm is considered acceptable .However, some authors suggest that 100–150 µm is acceptable for various restorations. [14] McLean and von Fraunhofer[15] recommended 120 µm as the maximum acceptable marginal gap value based on the results of a five-year study consisting of 1,000 restorations. In this study, mean marginal gap values of all study groups were below 120 µm, except for the control group. Control group also had an acceptable borderline value (120.1±33.1 µm).

Other studies have examined the marginal fit of porcelain crowns[16].The clinically acceptable limit of marginal gaps was reported between 100 and 120 µm. [17] It has been shown that high precision can be achieved using milling devices for densely sintered zirconia.[18] Systems milling densely sintered zirconia demonstrated marginal values of 60 and 74 µm.[19]

There are many methods to measure marginal adaptation. The preferred methods are microscopy and cross section. [20] In this study, a microscopic measurement method was chosen. Results were evaluated with a stereo microscope at 40 X zoom lens.

There are different ways to study and analyze the fit of dental restorations. [21] In other studies the frameworks were sectioned centrally to analyze the marginal and inner fit of the constructions. The thickness of the wax, storing time and operator skill are some risk factors that can lead to distortion. [22] To minimize some of these factors, the same operator performed the waxing and casting, and two persons examined and accepted the waxing. (23)

It was ascertained by earlier studies that SEM is the most reliable and realistic method to quantitatively measure the marginal fit of indirect restorations. (24) However, there have been earlier investigations, which employed digital microscopes, stereomicroscopes and profile projector to analyze the marginal fit .

In some in vitro studies, the zirconium oxide-based ceramic CAD/CAM systems mean marginal gap (10.62μm) was followed by the Empress system mean marginal gap (65.55 μm)which both demonstrated acceptable marginal gaps, the copy milling system (159.52 μm) produced unacceptable marginal gap according to who suggested that 120 μm should be the highest limit for clinically acceptable marginal discrepancies. The finding of Empress group could be explained by the fact that it was fabricated through a combination of the lost-wax and heat pressed techniques, and may undergo dimensional changes caused by the use of a separating medium before waxing of the core, the shrinkage occurring during solidification of the wax, and the dimensional changes occurring in the investment. (25)

The dimensional changes in glass-ceramic ingot when plasticized and pressed into an investment mould caused by the shrinkage after casting of the ingot could be related to the high fusing temperature which will cause greater fit discrepancy, and the expansion of the investment may be inadequate to compensate for the casting shrinkage and in turn obtaining a good fit. (26) The other cause of marginal gap on the Empress group could be attributed to different degree of surface roughness produced in the casting which was invested by investment material. Surface roughness will increase when using high mould temperatures.(27)

Other studies on marginal fit (14) detail their evaluations in different regions: labial, mesial, distal and lingual. In all cases, good marginal adaptation is a key to a successful restoration. The systems evaluated in this study, with the described methodology, show a lower marginal fit than other ceramic systems(18) probably because of technological development and new materials.

Similar methodologies to the one used in this study have been used to assess marginal fit. Some authors measured the samples both before and after cementing, using different loads and buco-lingually sectioning the samples.(19)Others reported higher marginal fit values in ceramic crowns and metal ceramic crowns.(27)

CONCLUSION

Within the limitations of this in vitro study, the internal precision of fitness of crown restorations is significantly better with zirconia core substructure than the IPS empress ceramic and NiCr cores.

REFERENCES

1. Kelly J. R, Nishimura I., Campbells S. D.: Ceramics in dentistry: historical roots and current perspectives. *J Prosthet Dent.* 75: 18–32, 1996.
2. Goldman M., Laosonthorn P., White R. R.: Microleakage , full crowns and the dental pulp *J Endod.* 18: 473–475, 1992.
3. Muller H. P.: The effect of artificial crown margins at the gingival margin on the periodontal conditions in a group of periodontally supervised patients treated with fixed bridges. *J. Clin. Priodontol.* 13(2): 97–102, 1986.
4. Silness J.: Periodontal conditions in patients treated with dental bridges. The relationship between the location of the crown margin and periodontal condition. *J. Periodontol Res.* 5: 225–229, 1970.
5. Leinfelder KF, Isenberge BP and Essig ME (1989). A new method for generating ceramic restorations: CAD/CAM system. JADA: 118,703-707.
6. Essig M, Isenberg BP, Leinfelder K (1997). Five-year clinical evaluations of CAD/CAM ceramic restorations.[abstract1201] *J Dent Res.* 76:164.
7. Reich S, Wichmann M, Nkenke E, Proeschel P (2005). Clinical fit of all ceramic three unit fixed partial dentures , generated with three different CAD/CAM systems. *Eur J Oral sci;* 113: 174-179.
8. Holmes JR, Bayne SC, Holland GA

(1989). Consideration in measurement of marginal fit. *J Prosthet Dent* 62: 405-408.
9. Balkaya MC, Cinar A, Pamuk S (2005). Influence of firing cycle on the margin distortion of 3 all ceramic crown systems. *J Prosthet Dent*; 93: 346-355.
10. Ihab Adel Hammad and Mohammad Al Amri (2008). The effect of two fit-indicating materials and various subsequent cleaning methods on the retention of simulated crowns. *J Prosthet Dent*; 99; 1:47-53. 29.
11. Sulaiman F, Chai J, Jameson LM, Wozniak WT. A comparison of the marginal fit of In-Ceram, IPS Empress, and Procera crowns. *Int J Prosthodont.* 1997;10(5):478–484.
12. MitsuyoshiTsumita, Yuji Kokubo, Chikahiro Ohkubo, Yuki Nagayama, Satoe Sakurai and Shunji Fukushima (2007). Clinical Evaluation of Marginal and Internal Gaps of Zirconiabased 3-unit CAD/CAM Fixed Partial Dentures. *Prosthodont Res Prac*t; 6 : 114-119.
Komine F, Gerds T, Witkowski S, Strub JR. Influence of framework configuration on the marginal adaptation of zirconium dioxide ceramic anterior four-unit frameworks. *Acta Odontol* Scand 2005; 65: 361-366.
13. Albert FE, El-Mowafy OM. Marginal adaptation and mikroleakage of procera all-ceram crowns with four cements. *Int J Prosthodont* 2004; 17: 529-535. 15.
14. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. *Br Dent J* 1971; 131: 107-111.
15. Sulaiman F, Chai J, Jameson LM, Wozniak WT. A comparison of the marginal fit of In-ceram, IPS Empress and Procera crowns. *Int J Prosthodont* 1997; 10: 478-484.
16. Boening KW, Walter MH, Reppel PD. Non-cast titanium restorations in fixed prosthodontics. *J Oral Rehabil* 1992; 19: 281-287.
17. Groten M, Grithofer S, Pröbster L. Marginal fit consistency ofcopy-milled all-ceramic crowns during fabrication by light and scanning electron microscopic analysis in vitro. *J Oral Rehabil* 1997; 24: 871-881.
18. Quante K, Ludwig K, Kern M. Marginal and internal fit of metal–ceramic crowns fabricated with a new laser melting technology. *Dent Mater* 2008;24:1311–5.
19. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. *Br Dent J* 1971;131:107–11. [23].
20. Sailer I, Fehér A, Filser F, Gauckler LJ, Lüthy H, Hemmerle CH. Five-year clinical results of zirconia frameworks for posterior fixed partial dentures. *Int J Prosthodont.* 2007;20(4):383–388.
21. Bindl A, Mormann WH. Marginal and internal fit of all-ceramic CAD/CAM crown-copings on chamfer preparations. *J Oral Rehabil*. 2005;32(6):441–447.
22. Tinschert J, Natt G, Mautsch W, Spiekermann H, Anusavice KJ. Marginal fit of alumina and zirconia-based fixed partial dentures produced by a CAD/CAM system. *Oper Dent* 2001;26:367–374.
23. Sailer I, Feher A, Filser F, Gauckler LJ, Luthy H, Hammerle CH. Five-year clinical results of zirconia frameworks for posterior fixed partial dentures. *Int J Prosthodont* 2007;20:383–388.
24. Groten M., Axmann D., Probster L., Webers H.: Verläßlichkeit von zirkulärenRandspaltmessungen an Einzelkronen. Deutsche ZahnärztlicheZeitschrift. 53: 260, 1998.
25. Lacy A. M; Mora A; Boonsiri I: Incidence of bubbles on samples cast in a phosphate-bonded investment. *J Prosthet Dent* 1985; 54(3):367-9.
26. Rekow ED, Zhang G, Thompson V, Kim JW, Coehlo P, Zhang Y. Effects of geometry on fracture initiation and propagation in all-ceramic crowns. *J Biomed Mater Res B ApplBiomater.* 2009;88(2)436–446.
27. Shirley H, Hung M, Kuen-Shan H, Eick D, Chappell R. Marginalfit of porcelain fused to metal and two types of ceramic crown. *J Prosthet Dent* 1990; 63: 26-31.