A study to compare the internal fitness and marginal gap between single crowns and crowns within three-unite bridge of zirconia substructure fabricated by CAD-CAM system. (An In vitro study)

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ABSTRACT

Purpose: the aim of this in vitro study was to compare the marginal gap and internal fitness between single crowns and the crowns within three-unit bridges of zirconium fabricated by CAD-CAM system.

Materials and methods: A standard model from ivoclar company was used as a pattern to simulate three-units bridge (upper first molar and upper first premolar) as abutments used to fabricate stone models, eight single crowns for premolar and eight of three units bridges. Crowns and bridges fabricated by CAD-CAM system were cemented on their respective stone models then sectioned at the mid-point buccolingaully and misiodistaly and examined under stereomicroscope.

Result: the marginal gap in premolar crowns and premolar within bridge were within the acceptable value 120µm, one –way ANOVA showed that there was significant differences in the internal gaps among the areas. Independent t- Test showed there was significant differences between the premolar crowns and premolar crowns within bridges in marginal opening and cusp tip (lingually and distally)

Conclusion: the marginal and internal gaps were in the bridge higher than those in the crowns. The areas of sloped surfaces such as chamfer area, occlusal area and cusp tip had high gap values in comparison with areas of flat surfaces such as axial wall and when the surface area of abutment increased, the marginal and internal gaps of abutment was increase.

Keywords: marginal fitness, internal fitness, CAD-CAM system, zirconia **(J Bagh Coll Dentistry 2017; 29(1):27-31)**

INTRODUCTION

All ceramic restorations can be used as a good alternative to the metal- ceramic restoration, especially with increasing the expectation to the esthetic restoration in addition to that, good mechanical properties and biocompatibility of ceramic restoration. Marginal and internal fit of restoration are factors to success , any discrepancy in margin led to secondary caries formation , periodontal destruction , pulpal irritation and dissolution of luting agent so that misfit reduce the longevity of restoration[(1)] . Nowadays, a high strength zirconia used in FPD even in load bearing area [(2,3)], which is present in either partially sintered or fully sintered zirconia and it is stronger than other types of ceramic such as lithium disilicate – reinforced glass ceramic.[(4)] The evolution and development of CAD-CAM system added to the dentist new and fast treatment modalities in the fixed partial denture aspect. The CAD-CAM system presented to scan, design and mill the fixed prosthesis.

CAD-CAM machining for construction of dental restorations are gaining popularity and are clinically proven. [(5)]

MATERIALS AND METHODS

Sample description: Standard model from (Ivoclar Company) was used as a pattern for construction stone model to simulate three – unite bridge (the maxillary first molar and maxillary first premolar) as abutment and (the maxillary second premolar missed). The reduction of the abutments were 1.5 mm of the occlusal surface and 1.2 mm of the axial according to the ivoclar prepared guide with chamfer finishing line all around to receive full coverage zirconium crowns (fig. 1). The same model was used to fabricate both the single premolar crowns and premolar crowns within bridges.

Figure 1: Model from ivoclar with prepared maxillary first molar and maxillary first premolar to simulate three- unites bridge.

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Impression procedure:

Sixteen impressions were taken to the model with polyvinylesiloxan impression material (Zhermack, Italy) to produce 16 stone model for the fabrication of (8) three-unites bridges , (8) maxillary first premolar zirconium single crowns. Putty–wash technique was used to take impression, after the impression procedure was completed; impressions were poured by using type IV dental stone (Zhermack. Italy). After that all stone models were inspected under the light to exclude any defects such as air bubbles, then labeled and fixed on the plaster base, ready for scanning to produce the bridges and crowns as in (figure.2).

Figure 2: stone model on the plaster base ready to the scanning.

Sample grouping:

The samples were divided into two groups (group no. 8):

Group A: eight CAD-CAM single zirconium crowns for maxillary first premolar.

Group B: eight CAD-CAM three – unit bridges zirconium from maxillary first premolar to the maxillary first molar.

Scanning and construction of the crowns and bridges: All of abutments were scanned by the Amanngerbach scanner device and designed by the software of the same system, the software setting was the same for all the abutments in crowns and bridges to get standardization. After the crowns and bridges design were completed, the order was given to the milling machine to mill the Amanngerbach pre- sintered zirconium block to produce the crowns and bridges then the crowns and bridges sintered by the Amanngerbach furnace.

Cementation, blocking and sectioning:

Crowns and bridges seated on their respective stone models (figure.3), overextended and under extended crown and bridges were excluded. Glass ionmer cement was used for cementation, the cement was painted on the internal surface of the crowns and bridges, the crowns and bridges were initially seated on the stone model by fingure pressure then 5 Kg weight was applied over (crowns and bridges – stone model unit) for 10 minutes to ensure complete seating, piece of wood was used for leveling. After the cementation procedure completed, crowns and bridges were blocked with clear acrylic resin to support the crown and bridges-stone unite during the sectioning.

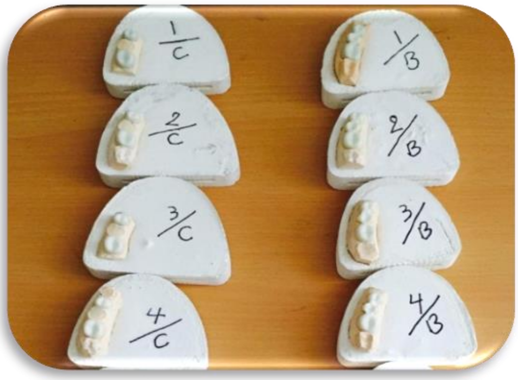

Figure 3: crowns and bridges seated on their respective stone model.

Crowns and bridges were sectioned longitudinally into four piece at midpoint buccolingaully and mesiodistaly according to pencil - line was drawn at the midpoint of abutment before sectioning [1], by sectioning machine with diamond disc (0.8 mm) with water coolant as in(figure .4) .

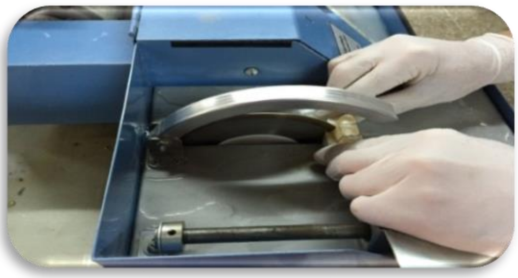

Figure 4: sectioning machine with water coolant.

Microscopical examination: After sectioning of the crowns and abutment of bridges, five point (marginal opening, chamfer area, mid- axial, cusp tip and mid- occlusal) selected to measure the marginal and internal fitness. The measurements were achieved by stereomicroscope provided with digital camera connected with computer at 120x magnification. Measurements were done by placing the sample on the microscope stage, which was adjusted until the image of the marginal and internal fitness was displayed clearly on the computer monitor, and the digital images of specimens were captured.

The image was treated with program (Image J), which was used to measure the marginal and internal fitness between the stone die and zirconium core as in(figure.5) .The records were done by two experienced persons and all records repeated two times to reduce the possibility of error. [6]

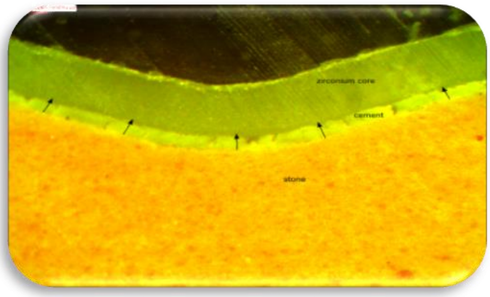

Figure 5: digital image show the border of zirconium core, glass ionmer cement and stone die under the microscope.

Statistical analysis:

The SPSS software package was used to perform the statistical analysis. One-way ANOVA (analysis of variance) test was carried out to see if there was any significant difference among the variables of groups. Independent t-test was carried out to detect the significant differences between the crowns and bridges in gap values.

RESULTS:

The measurements of marginal and internal fitness were (320) totally from two groups, eight upper first premolar crowns and eight of upper first premolar within three-unit bridges that include 20 measurements of each crown and abutments of bridges. The results showed that the maximum gap was found in the occlusal area while the minimum in the axial area, also there were differences between the premolar single crown and premolar crown within the bridge as in bar -chart (figure .6) and (table.1).

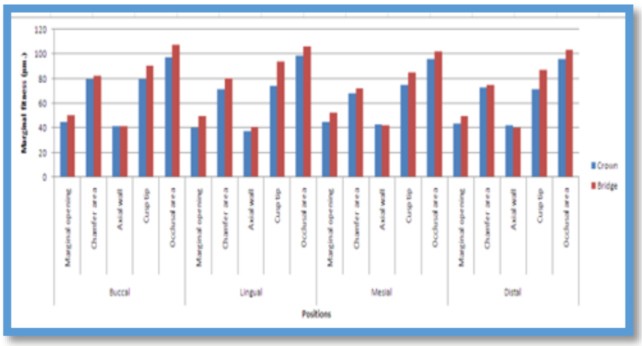

Figure 6: bar- chart showing the differences between the premolar single crowns and premolar within the bridge in marginal and internal fitness.

DISCUSSION:

Marginal and internal fitness are critical for the longevity of single or multiple-unit fixed-partial-dentures and the prognosis of the restored tooth. The solubility of luting agent restorative material leading to microleakage, plaque accumulation, caries and subsequent failure of the restoration [7]. In CAD/CAM or copy-milling systems, the marginal opening has been reported to range between 60 μm and 300 μm ,While a clinically acceptable value of marginal discrepancies is advised to be less than 120 μm[8]. For marginal and internal gaps of zirconia restorations, it was found that the fit of zirconia restoration is influenced by heterogeneity in terms of experimental methodology, milling system, manufacturers, sintering states of the zirconia, sample size and span length [9].

In this in vitro study there were differences in the fitness among the five positions within the same tooth. The maximum gap was found in the occlusal area while the minimum in the axial area, this may be because of the more complex shape of the occlusal surface. In addition, CAD/CAM software may not as precise as it should be. Therefore, it has to be considered that a tendency for the greater gaps than the expected value could be found [9]. There were differences in marginal and internal fitness between the single crown and the crowns within three – unite bridge zirconium framework, so the null hypothesis which stated that manufacturer's recommended parameters for CAD/CAM zirconia system were precise for all surface and in crowns and bridges not acceptable, and difference between the bridge and single crown due to larger dimension of bridge framework than those of single crown substructure, this was in agreement with this study [9,10] .

A study in 2001 reported that long span bridge had large values of marginal discrepancy but the values not significantly difference [11], this disagree with this study. Also, In this in vitro study, the small gap in the axial and marginal opening and large gap in the occlusal, cusp area and chamfer area, one possible explanation to that difference might be the entrapment of cement in the occlusal, chamfer and cusp area during cementation due to abscence of vent like that in cast restoration while in the axial and marginal opening there were a chance to exit out during cementation. In this in vitro study used the pre-sintered zirconium block to fabricate the crowns and bridges, about 20-30% shrinkage occur in the zirconium during the sintering. Some of studies reported that the shrinkage differ in different position within the same abutment ,there were study in 2007 studied the effect of shrinkage during sintering on the zirconium restoration and found the shrinkage in the tooth axis(margin and axial) smaller than the horizontal axis (cusp and occlusal area) ,also when the distance between the abutments increase , the marginal discrepancy will increase and the shrinkage of pontic may affect the marginal and internal fitness of the bridge[12] , this agree with this study. In this in vitro study, the differences between the premolar as single crown and premolar within the bridge were in marginal opening and there were differences in cusp tip lingually and distally, the possible explanation for this, it might due to bridge configuration and shrinkage of pontic led to more gap at lingual and distal side and less gap in buccal and mesial side. A study in 2007 evaluated the fitness of zirconium restoration clinically, they stated the shrinkage during sintering increase the chance of developing gap between the abutment and restoration especially in the bridge than the single crown because of more complex geometry of bridge [13]. This agree with this study.

CONCLUSION:

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

1. The mean marginal gaps of zirconium in both crowns and bridges within the acceptable range 120µm.
2. The marginal and internal gaps in the bridge higher than those in the crowns.
3. The areas of sloped surfaces such as chamfer area, occlusal area and cusp tip had high gap values in compare with area of flat surface such as axial wall.
4. When the surface area of abutment increased, the marginal and internal gaps would increase.

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Table (1): Comparing the marginal and internal fitness between Premolar single crown and premolar within the bridge.

Sides	Positions	Descriptive statistics				Comparison (d.f. = 14)	
		Premolar crown		Premolar bridge			
		Mean	S.D.	Mean	S.D.	t-test	p-value
Buccal	Marginal opening	44.825	6.848	50.663	5.756	-1.846	0.086 (NS)
	Chamfer area	79.950	5.219	82.338	10.661	-0.569	0.578 (NS)
	Axial wall	41.250	5.997	41.775	6.220	-0.172	0.866 (NS)
	Cusp tip	79.650	9.500	90.538	11.190	-2.098	0.055 (NS)
	Occlusal area	97.763	6.840	107.650	10.466	-2.237	0.042 (S)
Lingual	Marginal opening	40.388	6.665	49.700	6.360	-2.859	0.013 (S)
	Chamfer area	71.575	8.324	80.438	8.710	-2.081	0.056 (NS)
	Axial wall	37.713	4.640	40.638	7.143	-0.971	0.348 (NS)
	Cusp tip	74.413	7.504	94.363	15.120	-3.343	0.005 (HS')
	Occlusal area	98.750	6.250	106.625	8.809	-2.062	0.058 (NS)
Mesial	Marginal opening	44.713	7.171	52.588	5.977	-2.386	0.032 (S)
	Chamfer area	68.438	6.682	72.338	9.896	-0.924	0.371 (NS)
	Axial wall	43.263	5.562	42.525	7.618	0.221	0.828 (NS)
	Cusp tip	74.763	9.218	85.125	11.237	-2.017	0.063 (NS)
	Occlusal area	95.825	7.536	102.575	13.222	-1.254	0.230 (NS)
Distal	Marginal opening	43.838	5.984	50.025	5.332	-2.184	0.047 (S)
	Chamfer area	72.650	7.545	74.763	7.303	-0.569	0.578 (NS)
	Axial wall	42.375	6.513	40.213	5.120	0.738	0.473 (NS)
	Cusp tip	71.600	9.367	87.150	12.157	-2.866	0.012 (S)
	Occlusal area	96.125	7.209	103.300	9.769	-1.671	0.117 (NS)

الخلاصة:

الغرض من هذه الدراسة مقارنة الفجوة في حافات الأسنان والتركيب الداخلي بين التيجان والجسور المتكونة من ثلاث أسنان المصنعة من الزركونيا والمصممة بمساعدة الحاسوب \ والمنحوتة باستخدام الحاسوب .
تم تحضير ثمان عينات من التيجان للضواحك العليا وثمان أسنان للطواحن العليا وثمان جسور تتكون من ثلاثة أسنان وتكون الضواحك والطواحن العليا من ضمن أسنان الجسور وذلك باستخدام قالب جاهز مصنع من قبل شركة ايفوكلار وحسب مواصفاتها العالمية . تتكون مادة كل من الجسور والتيجان من الزركونيا وتم تصنيعها حسب مواصفات المصنع وباستخدام وتصميم الحاسوب والماكنة النحاتة . بعد إتمام عملية نحت التيجان والجسور تم وضعها على قوالبها الحجرية ولصقها بمادة كلاس ايونمر سمنت , بعد ذلك تم تقطيع العينات بواسطة ألة القطع إلى اربع قطع لغرض فحصها تحت المجهر وبواسطة الحاسبة لقياس الفجوة في الحافات والتركيب الداخلي ومقارنة النتائج بين التيجان والجسور باستخدام البرنامج الإحصائي أحادي الاتجاه (ANOVA) وبرنامج (Independent t-test).
أظهرت النتائج بان هنالك فرق في الفجوات بالتركيب الداخلي في نفس السن بأماكن مختلفة , وأيضا هنالك فرق في الفجوات في الحافات والتركيب الداخلي بين التيجان والجسور حيث ان الفجوات في الحافات والتركيب الداخلي للجسور تكون اكبر من تلك في التيجان , وان الفجوات في كل من الحافات في التيجان والجسور المصممة و المصنعة بواسطة الحاسوب- المنحوتة هي من ضمن الفجوات المقبولة سريريا.