Comparative Study of Marginal Gap Among Zirconium Dioxide, Poly Ethyl Ethyl Ketone and Porcelain Fused to Metal Implant Supported Crowns

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Abstract

Objective: Lifetime and clinical success of implant-supported crown are critically affected by the marginal gap. Marginal misfit may lead to microleakage, cement dissolution accumulation of bacteria, food, and oral debris, potentially causing gingival inflammation and peri-implantitis. The objective of this in vitro study was to compare the marginal gap of crowns made from three different materials.

Methods: A shouldered implant abutment was screwed to implant analog and scanned. Computer Aided Design-Computer Aided Manufacturing (CAD/CAM) was used to design crown. Zirconium dioxide, Poly ethyl ethyl ketone and porcelain fused to metal were used as materials to fabricate six crowns from each one respectively. Marginal gaps were measured by stereomicroscope at five points for all samples, measurements were recorded using Adobe Photoshop CC 2017 software, and the data were statistically analyzed and subjected to one-way ANOVA and Scheffe post hoc tests (p = 0.05).

Results: Mean marginal gaps of Zirconia crown were (786 ±794 µm) and for porcelain fused to metal were (883± 371µm), both groups were significantly different from Poly Ethyl ethyl ketone (2000 ±1026 µm) group, but there was no significant difference between Zirconium dioxide and porcelain fused to metal.

Conclusions: Within the limitations of this study, it was concluded that although the marginal gaps of the studied implant-supported restorations were in the clinically acceptable range, crowns made from Zirconia provide less marginal gap followed by porcelain fused to the metal crown while PEEK material had the largest gap.

Keywords: *Marginal Gap, CAD/CAM, Implant supported crowns*

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Introduction

Implant supported restoration are widely used to restore a missing tooth which includes both surgical and prosthetic phases. The introduction of CAD/CAM systems with the different materials and techniques had expanded the range of restorations used in dental practice[1].

Accurately fitted implant-supported restoration is essential for long term success and durability of restoration[2]. Unfitting fixed implant-supported crowns would cause many biological complications due to bacterial adherence to the excessive gap between the implant abutment and the restoration leading to peri-implantitis[1,3]. Mechanical complications also occur such as de-cementation, chipping of ceramic, or abutment screw loosing[4].

Many factors such as implant positioning, the accuracy of impression obtained, prosthetic material, crown design, clinician and technician experience affect the successful adaptation of the restorations[5].

The clinically acceptable marginal gap for CAD/CAM-fabricated fixed crowns had been reported by various studies between 17-118 µm[6–9]. However, an in vivo study conducted by McLean and von Fraunhofer[10] stated that the maximum clinically accepted marginal gap is 120µm based on the result of long term clinical study.

Durability and clinical success of implant-supported crown are critically affected by the marginal gap. Therefore, this study aimed to measure and compare the marginal gap of Zirconia, PEEK, and PFM crowns.

Materials and methods

A shouldered implant abutment was screwed to implant analog with 20-newton torque according to manufactural instruction (Nucleoss T6), then the implant analog was inserted perpendicular in a cylindrical resin block with 10 mm diameter and 20 mm length. The resin cylinder used as a holder during the study. The implant abutment scanned with laboratory scanner (S600 ARTI, Zirkonzahn GmbH, Gais, Italy). The scan data was then transferred to the CAD/CAM software to design a cemented crown.

Before fabrication of the crown, the five-axis milling machine (Zirkonzahn GmbH, Gais, Italy) was calibrated, and new burs were inserted. For the Porcelain Fused to Metal (PFM) crowns (n=6), the core was made from CAD/CAM milled wax blank (WAX IVORY, zirkonzahn GmbH, Gais, Italy). Then casting and porcelain veneering was followed in a conventional way.

While full anatomic zirconia and Poly Ethyl Ethyl Ketone (PEEK) crowns were fabricated using same Standard Triangle Language (STL) file. PEEK crowns (n=6), the PEEK CAD/CAM block (Tecno Med, zirkonzahn GmbH, Gais, Italy) was milled according to the manufacturer instructions. Whereas, Zirconia crowns (n=6) were milled using green-state zirconia block (ICE zircon, zirkonzahn GmbH, Gais, Italy). All zirconia crowns were sintered in a special furnace (Zirkonofen 600/V2, Zirkonzahn GmbH, Gais, Italy) at 1500°C for two hours according to manufacturers' recommendation.

Each crown was individually seated on the implant abutment and was examined for a vertical marginal gap. Five points of the evaluation were considered for each sample under a stereomicroscope with x20 magnification (MOTIC ST-39 C-N9GO, Hong Kong) and a photograph was taken using (Canon, EOS 550D, Tokyo, Japan) camera by a single operator. Measurements were recorded using Adobe Photoshop CC 2017 software.

Statistical analysis

Collected data were subjected to statistical analysis using one-way ANOVA and Scheffe post hoc tests with a significant level of 0.05 to determine the mean difference. Statistical analysis was performed with statistical software IBM® SPSS® statistics v23.0.

Results

Statistical analysis showed that zirconia-based crowns recorded the lowest mean marginal gap width (786 ±794 µm). While PEEK-based crown recorded the highest mean marginal gap width (2000 ±1026 µm), these differences were statistically significant ($p<.05$). The PFM-based crowns recorded mean marginal gap very similar to zirconia-based crowns (883 ±371 µm) with a non-significant statistical difference, as shown in Table 1.

When the mean of each point of the marginal gap was compared separately between the three crown materials, PEEK-based crowns showed significantly greater marginal gap at all the points than zirconia-based and PFM-based crowns as shown in Table 2.

Table1: Mean gap width at the five points with different type of materials examined.

Material	N	Mean	(±SD)	p (AONVA)	LSD groups	p (LSD)
PEEK	6	1999.74	(1026.48)	0.03	1 X 2	.017
ZIR	6	786.11	(793.56)		1 X 3	.025
PFM	6	883.49	(371.32)		2 X 3	.832
TOTAL	18	1223.11	(925.56)			

Table 2: Means of gaps with different type of materials examined.

Gap	Material	N	Mean	(±SD)	p (AONVA)	LSD groups	p (LSD)
Gap a	PEEK	6	2065.70	(1075.53)		1 X 2	0.009
	ZIR	6	682.87	(749.58)	0.018	1 X 3	0.019
	PFM	6	852.92	(456.82)		2 X 3	0.718
	Total	18	1200.49	(984.00)			
Gap b	PEEK	6	2106.45	(1048.00)		1 X 2	0.009
	ZIR	6	723.07	(712.59)	0.015	1 X 3	0.014
	PFM	6	820.72	(557.68)		2 X 3	0.835
	Total	18	1216.74	(992.27)			
Gap c	PEEK	6	2085.48	(1073.93)		1 X 2	0.013
	ZIR	6	782.92	(744.32)	0.024	1 X 3	0.022
	PFM	6	916.16	(439.94)		2 X 3	0.776
	Total	18	1261.52	(960.02)			
Gap d	PEEK	6	1965.29	(1013.42)		1 X 2	0.028
	ZIR	6	850.89	(875.34)	0.047	1 X 3	0.035
	PFM	6	902.22	(316.42)		2 X 3	0.912
	Total	18	1239.47	(914.46)			
Gap e	PEEK	6	1775.79	(955.14)		1 X 2	0.071
	ZIR	6	890.83	(910.28)	0.123	1 X 3	0.082
	PFM	6	925.42	(357.24)		2 X 3	0.940
	Total	18	1197.35	(852.60)			

Discussion

Crown adaptation is an essential factor in the long-term clinical success of implant-supported fixed prosthesis[3]. This research involved an in-vitro evaluation of vertical marginal gap of CAD/CAM fabricated crowns with three different materials. Evaluations were performed before cementation, to exclude the effect of dental cement, as it is well known that cementation procedure increases the marginal gap[5].

A non-destructive two-dimensional method for measurement of the marginal gap was used with the aid of stereomicroscope from limited positions to minimize geometrical changes exploration[11].

Although, PEEK crowns were fabricated using dental CAD/CAM systems with no sintering process, hence no post fabrication dimensional changes. It was expected to have better marginal fitness[12]. Previously published articles showed the superior marginal fit of PEEK-based restorations[11,12] However, the results of this study was controversy, in which, the mean marginal gap of the PEEK-based crown was inferior to zirconia and PFM-based crown.

McLean and von Frauenhofer reported a gap of less than 120 µm to be clinically acceptable[10]. However, another study reported that 100 - 200 µm is clinically acceptable for long term successful prosthesis[13]. The marginal gap in this study was far from what is acceptable, marginal gap. For fabrication of implant-supported prosthesis, various type of alloy could be used, with different mechanical properties and different coefficient of thermal expansion, which could be responsible for variation in marginal fit[5]. Furthermore, the milling

parameter applied and the type of milling machine used could be factors during marginal gap measurements.

When porcelain-fused to metal crowns were considered, Karl et al.[14] stated that ceramic veneering of the metal framework will cause an increase in the marginal gap and would have a negative effect on the precision of fit of implant-supported crowns. This could be due to the high temperature generated during porcelain firing[15].

Conclusions

The marginal gap of zirconia crowns was lower than both porcelain fused to metal crown and PEEK even all it was in clinically accepted values. Meanwhile, PEEK crowns Showed the largest marginal gap.

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