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Evaluate and Compare the Effect of Different Marginal Cement Space Parameter Setting in the CAD Software on the Marginal and Internal Fitness of Monolithic Zirconia Crowns with Different Types of Luting Agents (A comparative *in vitro* study)

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ABSTRACT

Objectives: The purpose of this in vitro study was to evaluate and compare the effect of different marginal cement space parameter setting in the CAD software on the marginal and internal fitness of monolithic zirconia crowns with different luting agent.

Materials and method: 48 sound human maxillary first permanent premolar teeth of comparable size and shape extracted for orthodontic purposes were collected and selected to be used in this in vitro study. All the dimensions of each crown were tested with using one way ANOVA in order to reduce the confounding variables.

The teeth samples were divided into two main groups according to the different marginal cement space parameter setting (n=24) as following: Group I: 0 cement space around the margin and additional cement space of 80 Mm starting 1mm above the finish lines of the teeth. Group II: 25 Mm cement space around the margin and additional cement space of 80 Mm starting 1mm above the finish lines of the teeth. Each group was subdivided into three subgroups according to the type of luting material (n=8) :(IA, IIA) cemented with Rely X™ Ultimate adhesive,(IB, IIB) cemented with Rely X™ Unicem 200 self-adhesive and (IC, IIC) cemented with conventional Riva luting plus glass ionomer. The standard preparation for full counter monolithic zirconia crown restorations was done with light chamfer finishing line 0.8mm, axial reduction 1-1.5mm,occlso-axial height 4mm (palataly and buccally) ,anatomical occlusal reduction and total convergence angle 6 degree. The teeth were scanned with inEos X5 extra -oral digital scanner (Sirona, Germany) , then fabricated with Sirona In-Lab MC X5 milling device. The internal and marginal fitness of crown was evaluated by direct measurement of cement film thickness through sectioning procedure using a digital microscope at a magnification of60 X at eleven different measuring points for each specimen, which represented four different areas of measurement (margin, chamfer, axial and occlusal).

Results: The results of this study showed that the different marginal cement space parameter setting used was significantly improve the marginal and internal adaptation of monolithic zirconia crown restoration .The Rely X™ Ultimate adhesive luting agent had a lowest mean value of marginal discrepancy as compared with the other types of luting agent that was used in this study. Conclusions: using of 25μm cement space at the marginal area resulted in reducing the marginal and internal gaps. The Rely X™ Ultimate adhesive luting agent provided the lowest marginal and internal gaps as compared with other types of luting used in this study.

Key words: Cement space, Hydraulic pressure, Marginal discrepancy

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INTRODUCTION

The success of all ceramic restorations depends mainly on the marginal and internal fitness. A good marginal fitness is anticipated to minimize accumulation of dental plaque, secondary caries, pulpitis, which subsequently lead to damage the tooth structures and its supporting periodontium, then the long life of crown restoration decreases [1,2]. These defects are common reasons for the failure of crown restorations [3]. Kasloff, et al. said in order to achieve an ideal restoration, the crown must be made to fit intimately over the prepared tooth [4,5]. The clinically, acceptable limit of the marginal discrepancies is reported to be less than 120 μm [6]. A number of factors might affect the fitness of crown restoration such as the degree of convergence angle of preparation, location of the margin (sub or supra-gingival), quality of scanner-milling device–milling bur, thickness of cement spacer, amount and viscosity of luting cement, seating aid procedures such as vibratory techniques and type of loading during cementation either static or dynamic [7-9]. White, et al. in their study showed that the marginal discrepancy was increased after cementation [10,11].

Pilo et al. said when the crown restoration precisely fits the prepared tooth, the escape pathway of cement between the crown restoration and prepared tooth surface become more difficult [5,12]. The final effects are creation of premature, occlusal contacts, inappropriate proximal contacts, marginal discrepancies and lack of coziness [5]. Many methods have been suggested previously in order to minimize post cementation marginal discrepancy.

These include:

1. Internal relief space [13,14], Many techniques have been suggested to provide the internal relief space, Hager et al. categorized the internal relief into subtractive and additive method [11,15]. Subtractive methods involve (a) Aqua regia etching was first discovered by Hollenback, et al. [16] (b) Internal mechanical grinding of castings (c) Internal carving of wax patterns before casting (d) Eelectrochemical milling [5,11,17]. The additive method involves application of die-spacer onto the stone die or use of tin foil [18].
2. Venting [19].
3. Cement escape channels [13].

From all above studies showed that the best and most popular method to improve seating of crown restoration was the internal relief with die spacer.

MATERIALS AND METHODS

Forty–eight sound human teeth (maxillary first permanent premolar) of comparable shape and size extracted for orthodontic purposes were collected to be used in this *in vitro* study. All teeth were then embedded individually in cold cure acrylic resin block 2 mm below the CEJ. Dental surveyor was used to align the long axis of the tooth to be vertical to the horizontal plane of the mold. In order to achieve a standardized preparation for all teeth, the preparation was carried out by one operator. A modified dental surveyor was used to prepare the axial walls of the tooth to gate a constant degree of tapering according to the tapering of the preparation and finishing burs used. All the teeth were prepared to receive the monolithic zirconia crown restoration with the following features of preparation: Light chamfer finishing line with uniform thickness of 0.8 mm in depth, axial reduction 1-1.5 mm, occlso-axial height 4 mm (palataly and buccally), anatomical occlusal reduction and total convergence angle 6 degree (Figure 1).

All the samples were scanned with the in Eos X5 extra-oral digital scanner (Sirona Dental Systems, Germany) with CEREC Premium software, version (16.1) to produce a 3D digital images for all the teeth, and randomly divided into two main groups I and II according to the design of cement space parameter (n=24): The cement space parameter in Group I was setted at 0 mm around the margin and additional cement space of 80 mm starting 1 mm above the finish lines of the teeth and for Group II was 25 mm around the margin and additional cement space of 80 mm starting 1 mm above the finish lines of the teeth (Figure 2).

Then the crowns were milled with the same milling machine MC X5 (Sirona Dental System, Germany), from pre-sintered monolithic KATANATM zirconia disc, then fired in fire HTC speed (Sirona, Germany), glazed and sandblasted with aluminum oxide particles ≤ (50 μm) at max. Pressure of 2.5 bars at a distance of 10 mm for 15 sec. Each main group was divided into three subgroups according to the type of cement material (n=8) :(IA,IIA) Rely X™ Ultimate adhesive luting agent(3M ESPE, Germany), (IB,IIB) cemented with Rely X™ Unicem 200 self-adhesive luting agent (3M ESPE, Germany) and (IC,IIC) conventional Riva luting plus glass ionomer cement (SDI, Australia).

The cement was painted over the entire surfaces then placed over its respective tooth with rocking movement and maximum index finger pressure as in the clinical situation. For the purpose of standardization, the crown with its respective tooth was then seated inside the sample holding and cementation device and was kept under load (5 kg) for 6 min. The internal and marginal fitness of crown was evaluated by direct measurement of cement film thickness in mm through sectioning procedure. The measurements were done using a digital microscope at a magnification of 60 X with (Dino-capture) software and Image J software (version 1.5) (U.S. National Institutes of Health, Bethesda, MA, USA) at eleven different measuring points for each specimen, which represented four different areas of measurement (margin, chamfer, axial and occlusal) (Figure 3).

RESULTS

The descriptive statistical results for all subgroups showed, the highest mean value of the gap was recorded at the occlusal area. While the lowest mean value of the gap was recorded mostly at the marginal area (Table 1). T-test showed that different cement space designs were significantly affect both marginal and internal fitness of the tested monolithic zirconia crown restoration (p=0.000) (Table 2) while the result of 1-Way ANOVA test indicated that different

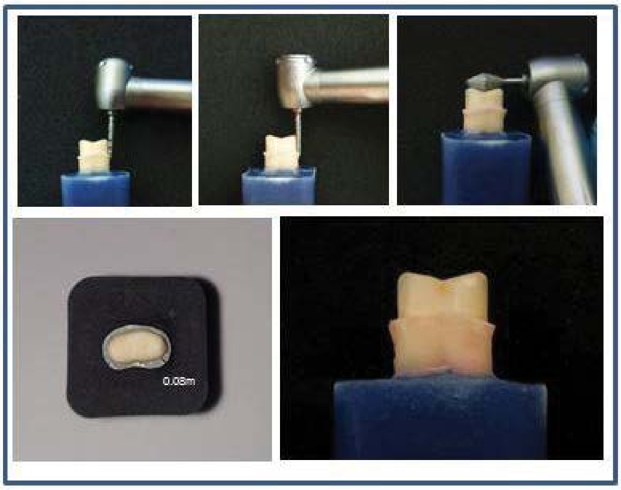

Figure 1: Tooth preparation.

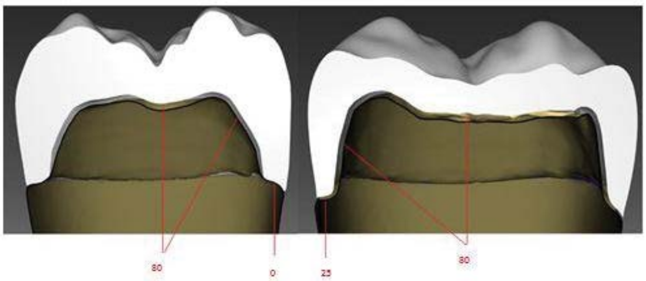

Figure 2: Cement space parameter settled in CAD software.

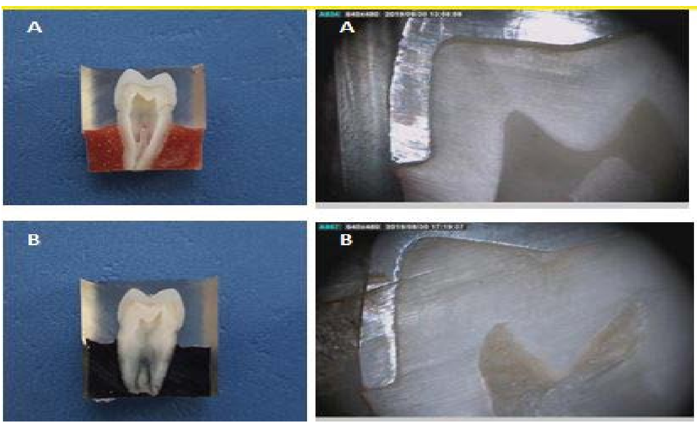

Figure 3: A: 0µm marginal cement space. B: 25 µm marginal cement space.

Table 1: Descriptive statistics of the gap at the different areas of the six subgroups measured in µm.

Groups	Subgroups	Areas	N	Mean	Std. Deviation	Minimum	Maximum
Group I	A	Marginal	8	61.12	5.14	56.02	68.2
		Chamfer	8	75.17	5.78	67.29	85.19
		Axial	8	87.34	8.77	71.3	99.83
		Occlusal	8	138.86	12.56	120.14	151.71
		Internal	8	95.45	3.58	88.76	99.82
	B	Marginal	8	76.68	4.1	70.14	82.04
		Chamfer	8	76.36	7.8	65.3	89.9
		Axial	8	92.1	5	83.38	96.46
		Occlusal	8	146.93	9.51	129.31	159.06
		Internal	8	105.58	4.8	97.17	114.41
	C	Marginal	8	70.85	6.53	61.36	80.53
		Chamfer	8	74.53	2.94	68.3	76.97
		Axial	8	98.32	9.76	82.47	109.09
		Occlusal	8	137.04	16.09	113.56	159.82
		Internal	8	102.88	5.29	93.57	109.52
Group II	A	Marginal	8	45.17	4.85	37.34	50.23
		Chamfer	8	58.23	6.65	46.83	65.28
		Axial	8	56.59	8.61	45.48	66.66
		Occlusal	8	64.36	9.73	54.68	83.82
		Internal	8	63.47	7.42	54.88	74.89
	B	Marginal	8	50.32	3.26	46.02	55.12
		Chamfer	8	47.87	11.18	32.64	59.91
		Axial	8	54.66	5.17	48.88	65.15
		Occlusal	8	71.72	4.37	65.05	79.74
		Internal	8	58.08	4.81	50.01	65.19
	C	Marginal	8	54.79	3.2	51.13	60.08
		Chamfer	8	58.41	6.79	50.12	69.33
		Axial	8	59.75	5.32	50.47	65.3
		Occlusal	8	65.3	4.39	60.35	73.21
		Internal	8	60.73	4.96	55.31	69.25

Table 2: T-test for comparison of the marginal and internal gaps between the each corresponding subgroups of the two main groups.

Subgroups	Area	Groups	N	Mean	Std. Deviation	t	Sig.
A	Marginal	I	8	61.12	5.14	6.38	0
		II	8	45.17	4.85		
	Internal	I	8	95.45	3.58	10.99	0
		II	8	63.47	7.42		
B	Marginal	I	8	76.68	4.1	14.22	0
		II	8	50.32	3.26		
	Internal	I	8	105.58	4.8	19.76	0
		II	8	58.08	4.81		
C	Marginal	I	8	70.85	6.53	6.25	0
		II	8	54.79	3.2		
	Internal	I	8	102.88	5.29	16.43	0
		II	8	60.73	4.96		

types of luting agents were significantly affect the adaptation of zirconia crown ($p \leq 0.005$). The Turkey HSD test revealed statistical differences between group IA-IB, IA-IC in both marginal and internal areas, while difference between IB- IC in the marginal area only. On the other hand, these differences noticed between IIA-IIB and IIA-IIC in marginal area only (Table 3). The Pearson's correlation test was showed a moderate positive correlation between the marginal and internal gaps within Group I and weak negative correlation within Group II (Table 4).

Table 3: Turkey test for compassion of marginal and internal gps among subgroups (according to the type of luting agent).

Areas	Groups I		Mean Difference (I-J)	Std. Error	Sig.
Marginal	IA	IB	-15.55750*	2.6762	0.000 (HS)
	IA	IC	-9.72750*	2.6762	0.004 (S)
	IB	IC	-9.72750*	2.6762	0.004 (S)
internal	IA	IB	-10.12375*	2.30743	0.001 (HS)
	IA	IC	-7.42625*	2.30743	0.011 (S)
	IB	IC	2.6975	2.30743	0.484(NS)
Areas	Groups II		Mean Difference (I-J)	Std. Error	Sig.
Marginal	IIA	IIB	-5.15000*	1.92236	0.036 (S)
	IIA	IIC	-9.61375*	1.92236	0.000 (HS)
	IIB	IIC	-4.46375	1.92236	0.075(NS)
internal	IIA	IIB	5.39	2.92623	0.181(NS)
	IIA	IIC	2.7375	2.92623	0.624(NS)
	IIB	IIC	-2.6525	2.92623	0.642(NS)

Table 4: Correlation between marginal and internal gap of the two main groups.

Groups	r	p value	Sig.
I	0.604	0.004	HS
II	-0.381	0.066	NS

DISCUSSION

The results of this study showed that a different marginal cement space parameter setting and different types of luting agents used were significantly affect the marginal and internal fitness of monolithic zirconia crown restoration, thus the null hypothesis was rejected. The statistical results revealed that using of 25 µm spacer instead of 0 µm around the marginal area could reduce the value of marginal and internal discrepancies, this result can be explained by the fact that using 25 µm space at the margin lead to increase the escape pathway of luting material and reducing the hydraulic pressure that was generated within the crown, thus improving the marginal and internal adaptation of the monolithic zirconia crown. Also some author in their studies showed the setting of spacer at 0 µm around the marginal area was leading to intimate contact between the fitting surface of restoration and tooth preparation at the marginal area of finishing line [9,13,14,20]. Resulting in increased the frictional resistance at that area, then increasing the hydraulic pressure and incomplete seating, this finding can be clearly supported when comparing the occlusal film thickness of spaced and unspaced groups at the marginl area. Occlusal film thickness recorded with 25 µm spacer had been reduced to the half that recorded with 0 µm as shown in Table (1).

In order to have a complete picture about the crown seating, different levels of adaptation (marginal, chamfer, axial, occlusal) were evaluated and comparing among them regarding the type of luting agent [21,22,23,24].

Regarding the spacer of 0 µ, when comparing statistical results of its subgroups Table (1), it had been noticed that the lowest mean value of the marginal gap measurement was mainly in subgroups cemented with Rely X™ Ultimate adhesive luting agent followed by conventional Riva luting plus glass ionomer cement.

While the spacer of 25 µ, it had been observed that the lowest mean value of the marginal gap measurement was mainly in subgroups cemented with Rely X™ Ultimate adhesive luting agent followed by Rely X™ Unicem 200 self-adhesive luting agent.

This result could be due to:

1. Low film thickness of Rely X TM Ultimate adhesive luting agent (12 µm) when compared with the other two cements: Rely X™ Unicem 200 (18 µm) and Riva luting plus GIC (17 µm).
2. High flow- ability of Rely X TM Ultimate adhesive luting agent when compared with the other two cements that were used in this study due to has a low viscosity and fine particle size as compared with the other mentioned cements [12,25,26,27].
3. From the results mentioned above, showed that the new spacer design used in this study was attributed to improve the seating of monolithic zirconia crown even, with the cement which had a highest film thickness

among the other cements used in this study, that recorded a highest mean gap values with the traditional CAD/CAM design.

The correlation test between the marginal and internal gap for Group I revealed a moderate positive relation between them, with highly statistical significant difference, the positive person`s correlation means that when the marginal gap increased, the internal gap increased. This could be due to the fact that all the steps of teeth preparation and crown fabrication were done under highly controlled and standardized condition. This finding was in agreement with the study of other previous studies who all found a positive relation between the marginal and internal gaps [22,23,28]. From a clinical point of view, this may give an indication that any crown restoration with poor marginal adaptation will mostly have poor internal adaptation.

While the correlation test for Group II revealed a weak negative relation between them, with no statistical significant difference (the negative person`s correlation means that the relation between the marginal ad internal gaps was inverse). This finding is in agreement with study of Borba [28] that showed a negative correlation between the marginal and internal gaps, and found an additional adaptation procedure in the internal area that would not significantly improve restoration fit in the marginal area. The mean values of the marginal and internal gaps of the two main groups of this study fall within the clinically acceptable limits. The direct comparison of the results of this study with the other studies was not available, because there were no other comparable published studies available.

CONCLUSION

The using of a spacer at the marginal area of the finishing line results in reducing marginal and internal gaps when compared with spacer free design at the marginal area. The Rely X™ Ultimate adhesive luting agent provided the lowest marginal and internal gaps as compared with other types of cement used in this study.

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