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"Marginal Adaptation of CAD/CAM PMMA Provisional Restorations Fabricated Using Various Digital Die Spacer Settings- An in vitro study"

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ABSTRACT:
Aim: The aim of this study was to compare the marginal gaps of CAD/CAM milled poly(methyl methacrylate) (PMMA) crowns fabricated using different cement space values in CAD/CAM.
Materials and Methods: An extracted maxillary premolar tooth was prepared with a shoulder margin. It was scanned using an intra oral scanner (Dentsply Sirona). The PMMA crown was designed using the scanned STL file with CAD software (Dentsply Sirona). The cement space was set as 80 µm for occlusal space and 40 µm , 50 µm, 60 µm and 70 µm as radial spacer. PVS material was\ used for the purpose of cementation based on the replica technique. From each replica , 4 sections were obtained . Each of the section was transferred on a trinocular stereomicroscope and images were clicked for each of them by using a digital camera. images were transferred to software and the vertical marginal gap was measured for each section. One-way analysis of variance (ANOVA) was used to analyse the data, and the post hoc Tukey multiple comparison test was performed.
Results: The mean marginal gap obtained was smaller when the cement gap was increased ($P < .001$). The mean marginal gaps for cement spaces of 40 µm, 50 µm, 60 µm and 70 µmwere 67.34 µm, 62.42 µm, 53.15 µm, 43.39 µm respectively, which were significantly different from each other**.**
Conclusion: ; As the crowns were designed and milled with increased cement space thickness, the vertical marginal gap values gone decreasing ($P < .001$); the smallest marginal gap values were observed when the 70-µm cement space setting was used ($P < .001$).

I.INTRODUCTION:

Marginal adaptation of crowns over the prepared teeth plays critical role in fixed dental prosthesis. Open margins on a crown can cause microleakage, which may lead to de cementation through dissolution of the cement. These parameters are critical for the success of both provisional and permanent crowns, on natural teeth as well as implants. Provisional restorations are a critical part of fixed prosthesis treatments, and allow maintenance of necessary gingival tissue, natural teeth, and implant health, as well as provision of gingival and temporomandibular joint (TMJ) treatments, and the return of any traumatized soft tissues to optimal health.[1] Marginal and internal fit of crowns play an important role in the long-term success of these restorations.[2]

Provisional restorations provide useful diagnostic value through assessment of functional, aesthetic, and occlusal parameters before the completion of the definitive restoration.[3] Marginal misfit may cause plaque retention, bacterial contamination, and related periodontal problems, in addition to delayed or inadequate healing of traumatized soft tissues.[1]Computer-aided design/computer-aided manufacturing (CAD/CAM) restorations are being used on large scalebecause of their efficient fabrication procedures,accuracy, and reduced laboratory time compared with conventional fabrication processes. These systems also allow the restoration thickness and simulated die spacer (cement space) to be set to the desired thicknesses.It was reported in several studies that die spacer thickness, finish line design, and type of cement may affect the marginal fit of CAD/CAM restorations.[5] These digital technologies that rely on exact dimensional predictions are claimed to demonstrate improved marginal adaptation.[6]

However, some CAD/CAM systems with poor scan quality and inadequate design software have been reported to produce crowns with unacceptable marginal gaps.[5]Several studies consider marginal openings from 50 to 120 µm as clinically acceptable for fixed restorations, with the range coming down to 50 to 100 µm for CAD/CAM restorations.The marginal gap of provisional crowns fabricated using different materials with the CEREC CAD/CAM system in a study by Abdullah et al ranged between 47 and 193 µm, though the mean marginal gap was within the acceptable limits of the 50- to 60-µm range. Internal cement space directly influences the crown fit, depending on the precision of the system.[1] The ideal cement space setting was reported to be 50 µm in the literature; 30 µm to create space for cement, with a theoretical cement space thickness between 25 and 40 µm28,29; and an additional 20 µm to compensate for manufacturing errors. It was shown in several studies that the marginal gap is reduced when cement space is increased, either digitally or through additional application of die spacer layers.[7]

The aim of this study was to compare the marginal gaps of CAD/CAM milled poly(methyl methacrylate) (PMMA) crowns fabricated using different cement space values in CAD/CAM . The null hypothesis was that there is no difference in the marginal fit of the crowns fabricated using different cement space thickness values.

II.MATERIALS AND METHODS:

An extracted maxillary premolar tooth was mounted on acold cure acrylic resin (DPI RR Cold Cure). It was prepared with a shoulder margin using an air-rotor handpiece with water and air coolant . It was scanned using an intra oral scanner (Dentsply Sirona). The PMMA crown was designed using the scanned STL file with CAD software (Dentsply Sirona). The cement space was set as80 µm for occlusal space and 40 µm , 50 µm, 60 µm and 70 µm as radial spacer. These values are similar to the ones reported in the literature for various CAD/CAM cement space settings.[1]

After finalizing the crown design, it was sent to CAM software, and PMMA crowns were milled from blocks (CAD Acryl) (n = 5 for each cement space thickness ; N = 20). After milling, a polyvinyl siloxane light body (PVS) impression material (Aquasil, Dentsply) was injected into the intaglio surface of the crown and it was then supported with the help of a polyvinyl siloxane (PVS) putty impression material (Aquasil, Dentsply). This PVS material used for the purpose of cementation is based on the replica technique for marginal gap measurement, previously described in the literature.[8]

For the measurement of the marginal gap following procedure was used; The prepared silicone replicas were indexed at four sites using a marking pen—midfacial, mid-palatal, midmesial, and middistal surface and all of them were cut at these sites. From each replica , 4 sections were obtained in this way. Each of the section was then transferred on a trinocular stereomicroscope and images were clicked for each of them by using a digital camera (Nikon 3500 DSLR Camera). A total of 20 images obtained for each of 4 groups.All the images transferred to digimizer image analysis program version 5.3.4, medcalc software and the vertical marginal gap was measured for each section

Normality of numerical data was checked using Shapiro-Wilk test & was found that the data followed a normal curve; hence **parametric tests** have been used for comparisons.

✓ Inter group comparison (>2 groups) was done using one way ANOVA followed by pair wise comparison using post hoc test.

For all the statistical tests, $p<0.05$ was considered to be statistically significant, keeping α error at 5% and β error at 20%, thus giving a power to the study as 80%.

III.RESULTS:

Results of one-way ANOVA indicated that the different cement gap settings significantly affected the marginal gap values ($P < .001$) [Table 1]. The mean marginal gap obtained was smaller when the cement gap was increased ($P < .001$)[Fig 1]. The mean marginal gaps for cement spaces of 40 µm, 50 µm, 60 µm and 70 µm were 67.34 µm, 62.42 µm, 53.15 µm, 43.39 µm respectively, which were significantly different from each other

Table1:Inter group comparison of values at all sites and mean

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	F value	p value of one way ANOVA
					Lower Bound	Upper Bound				

Mesial	1	5	106.920000	4.6202814	2.0662526	101.183163	112.656837	100.7000	112.7000		
	2	5	98.340000	1.8022209	.8059777	96.102247	100.577753	95.4000	99.8000		
	3	5	77.840000	3.2646592	1.4600000	73.786390	81.893610	74.0000	82.7000	244.840	.000**
	4	5	54.284000	3.1167740	1.3938637	50.414014	58.153986	50.1000	57.4000		
Distal	1	5	107.0600	2.90482	1.29908	103.4532	110.6668	104.90	112.00		
	2	5	93.9600	2.86583	1.28164	90.4016	97.5184	90.00	97.80	239.004	.000**
	3	5	74.4600	4.33336	1.93794	69.0794	79.8406	70.00	81.20		
	4	5	58.9980	1.45929	.65261	57.1861	60.8099	57.00	60.40		

Buccal	1	5	106.440000	2.9871391	1.3358892	102.730977	110.149023	102.2000	109.0000		
	2	5	96.040000	3.5514786	1.5882695	91.630257	100.449743	90.6000	99.8000	230.990	.000**
	3	5	79.200000	.9695360	.4335897	77.996162	80.403838	77.9000	80.2000		
	4	5	58.322000	3.9774892	1.7787872	53.383295	63.260705	54.0100	63.7000		
Lingual	1	5	106.940000	3.9715236	1.7761194	102.008702	111.871298	102.5000	112.0000		
	2	5	93.600000	3.4949964	1.5630099	89.260389	97.939611	90.8000	99.2000		
	3	5	74.540000	4.0826462	1.8258149	69.470725	79.609275	70.0000	80.9000	152.050	.000**
	4	5	55.092000	4.7591880	2.1283736	49.182688	61.001312	50.0600	61.0900		
Mean	1	5	67.33714	.799719	.357645	66.34416	68.33013	66.329	68.186		
	2	5	62.42000	1.114038	.498213	61.03674	63.80326	61.186	63.429	467.133	.000**
	3	5	53.14857	1.231085	.550558	51.61998	54.67717	52.014	54.514		
	4	5	43.38514	1.180988	.528154	41.91875	44.85153	42.196	45.326		

There was a statistically highly significant difference seen for the values between the groups (p<0.01) for

Mesial with higher values in group 1
Distal with higher values in group 1
Buccal with higher values in group 1

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Lingual with higher values in group 1

Mean with higher values in group 1

Table 2

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Mesial	1.433	3	16	.270
Distal	1.292	3	16	.311
Buccal	2.238	3	16	.123
Lingual	.371	3	16	.775
Mean	.711	3	16	.559

Although Levene **Test of Homogeneity of Variances resulted in a homogeneous variance, however Robust Tests of Equality of Means like Welch & Brown-Forsythe were carried out too.**

Table 3

		Statistic[a]	df1	df2	Sig.
Mesial	Welch	253.362	3	8.394	.000
	Brown-Forsythe	244.840	3	11.997	.000
Distal	Welch	406.041	3	8.220	.000
	Brown-Forsythe	239.004	3	11.381	.000
Buccal	Welch	178.402	3	7.507	.000
	Brown-Forsythe	230.990	3	11.975	.000
Lingual	Welch	119.547	3	8.843	.000
	Brown-Forsythe	152.050	3	15.242	.000
Mean	Welch	456.052	3	8.741	.000
	Brown-Forsythe	467.133	3	14.829	.000

a. Asymptotically F distributed.

$p<0.05$ indicated non similarity in means & variances

So an appropriate Post hoc test Games-Howell was decided for par wise comparison

Table 4

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Mesial	1	2	8.5800000*	2.2178819	.040*	.510912	16.649088
		3	29.0800000*	2.5300198	.000**	20.766075	37.393925
		4	52.6360000*	2.4924398	.000**	44.390622	60.881378
	2	3	20.5000000*	1.6676930	.000**	14.793937	26.206063
		4	44.0560000*	1.6101106	.000**	38.592306	49.519694
	3	4	23.5560000*	2.0185282	.000**	17.088766	30.023234
Distal	1	2	13.10000*	1.82488	.000**	7.2558	18.9442
		3	32.60000*	2.33307	.000**	24.8745	40.3255

		4	48.06200*	1.45379	.000**	43.0018	53.1222
	2	3	19.50000*	2.32340	.000**	11.7906	27.2094
		4	34.96200*	1.43823	.000**	29.9683	39.9557
	3	4	15.46200*	2.04487	.003**	7.8540	23.0700
Buccal	1	2	10.4000000*	2.0753795	.005**	3.708745	17.091255
		3	27.2400000*	1.4044928	.000**	21.987838	32.492162
		4	48.1180000*	2.2245638	.000**	40.865055	55.370945
	2	3	16.8400000*	1.6463900	.001**	10.551748	23.128252
		4	37.7180000*	2.3846769	.000**	30.058993	45.377007
	3	4	20.8780000*	1.8308697	.001**	13.805142	27.950858
Lingual	1	2	13.3400000*	2.3659248	.002**	5.735195	20.944805
		3	32.4000000*	2.5471945	.000**	24.241556	40.558444
		4	51.8480000*	2.7721064	.000**	42.904894	60.791106
	2	3	19.0600000*	2.4034558	.000**	11.320982	26.799018
		4	38.5080000*	2.6406389	.000**	29.874741	47.141259
	3	4	19.4480000*	2.8042065	.001**	10.419881	28.476119
Mean	1	2	4.917143*	.613292	.000**	2.90612	6.92816
		3	14.188571*	.656525	.000**	12.00399	16.37315
		4	23.952000*	.637853	.000**	21.84309	26.06091
	2	3	9.271429*	.742516	.000**	6.88819	11.65467
		4	19.034857*	.726060	.000**	16.70794	21.36178
	3	4	9.763429*	.762929	.000**	7.31929	12.20757

There was a statistically highly significant difference seen for the values between the groups ($p<0.01$) for
Mesial between all the pairs of groups (1 vs 2, $p<0.05$)
Distal between all the pairs of groups
Buccal between all the pairs of groups
Lingual between all the pairs of groups
Mean between all the pairs of groups

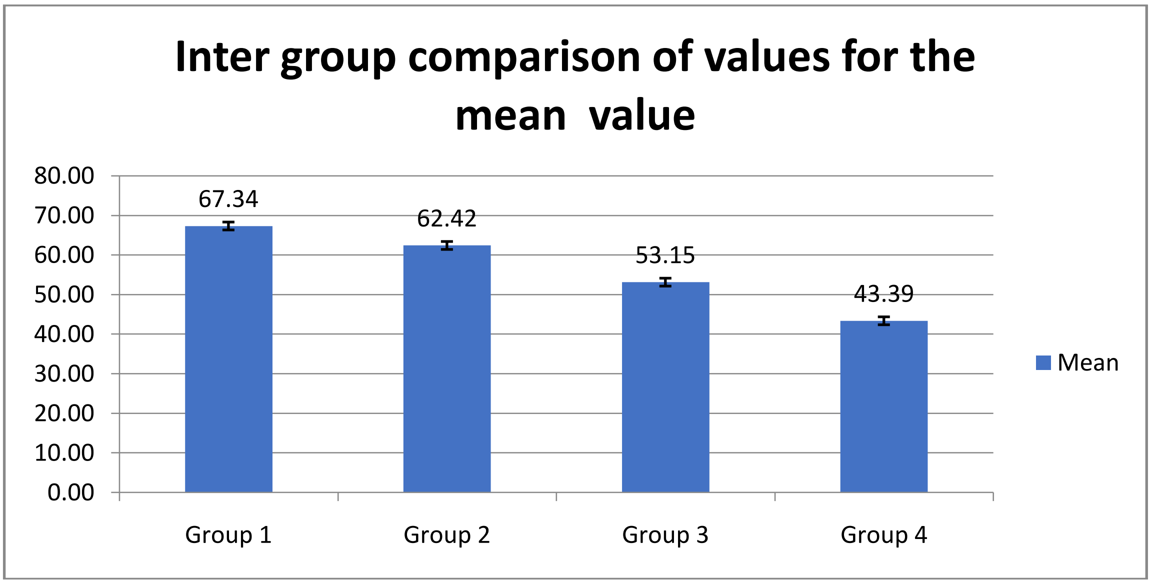

Fig 1

IV.DISCUSSION:

The null hypothesis of this study was rejected. There was significant difference among PMMA crowns vertical marginal gaps when different cement space thickness settings were used (P < .001). The smallest marginal gaps 43.39 µm were observed when the 70 µm cement space setting was used (P < .001). This mean value is within the recommended marginal gap range reported by Euán et al[9])Abdullah et al,[8]]Vojdani et al, [10]. The marginal gap values (67.34 µm) measured with the 40 µm cement space setting was less than the commonly reported clinically acceptable highest marginal gap value of 120 µm.[8-10] Though some studies in the literature have reported marginal and internal gap width values in the range of 50 to 200 µm, suggesting a lack of a clear scientific evidence-based objective limit, 50 to 100 µm for internal fit and 120 µm for the marginal gap is considered the practical range of clinical acceptability in most studies.[8-10]

Digital scanners enable fabrication of crowns with clinically acceptable marginal gaps.[8,9]The reason for the selection of a natural tooth as the test material was to eliminate the potential dimensional stability and wear issues reported in the literature when acrylic resin, stainless steel, or stone tooth models were scanned and crowns were tried on those dies.[1]Moreover, the results generated from this study can be employed for natural teeth crown.[1]

The fit of provisional restorations is an important clinical requirement for the successful maintenance of the overall health of the prepared tooth structure as well as the periodontal tissues around. Also, in the case of poor marginal adaptation of provisional restorations, the definitive restoration may be delayed, or the gingival appearance may not turn out as expected after the definitive restoration is delivered, especially in the esthetic zone. Thus, a well-fitting provisional crown directly affects the success of the definitive restorations to be delivered.[1] Because it was reported that horizontal misfit may potentially be adjusted more easily than the crown vertical misfit, the aim was to test vertical misfit in this study.[11]Two sets of techniques have been reported in the literature to measure marginal and internal gaps: cementation, embedding, and sectioning specimens for measurement; and using PVS for cementation and non invasive measurement of this PVS replica of the internal and marginal gaps.[8] The measurements were made using a modified form of the PVS replica technique, as has been previously described in the literature.[4,8] The study on PMMA crowns showed similar results to the previously conducted studies evaluating definitive restorative materials.

CONCLUSION:

Within the limitations of this study, the marginal gap values for the PMMA crowns were within the clinically acceptable range for 40-µm, 50-µm, 60-µm and 70-µm cement space thickness settings; As the crowns were designed and milled with increased cement space thickness, the vertical marginal gap values gone decreasing (P < .001); the smallest marginal gap values were observed when the 70-µm cement space setting was used (P < . 001).

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