Original Research

Effect of Cement-Space Thickness on the Marginal Fitness of All Zirconium Oxide Crowns—An *In Vitro* Study

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Abstract

Aim: To estimate the influence of cement-space thickness on the vertical marginal fitness of full zirconia crowns. **Materials and Methods:** A total of 24 newly extracted sound human maxillary first premolars were mounted and thereafter prepared to receive fully contoured zirconia crowns. Teeth were scanned via Chairside Economical Restoration of Esthetic Ceramic (CEREC) digital intraoral scanner (Omnicam, Sirona, Germany). Afterward, teeth were randomly assorted into three groups (depending on the cement-space thickness parameter of their corresponding designed crowns): group A = 80 μm, group B = 100 μm, and group C = 120 μm. Zirconia crowns were assembled using In-Lab MCX5 milling machine (Sirona). The cementation procedure was undergone using RelyX Unicem self-adhesive luting cement (3M, ESPE, Germany). The marginal discrepancy was measured at 16 points/tooth utilizing a digital microscope (85× magnification). Data were statistically analyzed utilizing one-way analysis of variance (ANOVA) and Tukey honestly significant difference (HSD) test ($P = 0.05$). **Results:** The analysis revealed that the cement-space thickness parameter had a highly significant effect on the marginal gap values in all groups. The lowest mean of marginal gap values was noted for group C (120 μm). **Conclusion:** Increasing cement-space thickness from 80 μm to 100 and 120 μm might be favorable for a better adaptation of monolithic zirconia crowns.

Keywords: Cement-Space, Marginal Fitness, Zirconia

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Introduction

Accurately fabricated restoration might barely be differentiated from a sound tooth; thus, patients' demand for such restoration greatly increased.[1] Zirconia gathers the esthetic qualities present in metal-free restoration, and because of its high strength, it is indicated for both posterior and anterior dental bridges.[1,2] With the development of computer-aided device–computer-aided machine (CAD-CAM) technology, the application of zirconia in dentistry rapidly increased.[2] This technology has been shown to save laboratory time, fabrication, and material cost, and it allows for easier parameters adjustment (e.g., cement-space and material-thickness) during the restoration designing.[2,3]

One of the fundamental keys for long-term clinically successful ceramic restoration is the internal and marginal fit. Any excessive marginal discrepancy would increase the susceptibility of cement dissolution at the area, which may promote microleakage, secondary caries, pulpal, and periodontal complications.[4,5] Different reference values for the adequate marginal gap are defined as clinically satisfactory; however, most studies agreed that adequate fit could be obtained when it is 120 μm or below.[6,7]

Even though increasing cement-space thickness during the restoration designing phase would facilitate cement distribution[7] and might improve the crown's fitness after cementation,[2,8] excessive internal gap might reduce the fracture resistance of the crown without significant improvement in its fitness.[9,10] However, a clear decision of the exact, clinically acceptable marginal gap value had not

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been verified yet[2,11]; this might be attributed to the internal cement-space provision, which could be system-sensitive.[2]

The purpose of the present study was to estimate the influence of the cement-space thickness parameters on the marginal fitness of zirconium oxide crowns cemented with self-adhesive luting cement. The hypothesis tested stated that the variation in cement-space thicknesses would not affect the marginal fit of CAD-CAM-fabricated monolithic zirconia crowns.

Materials and Methods

In this *in vitro* study, several extracted human upper first premolar teeth were collected from patients aged 18–24 years old in the Iraq-Basra population (the extractions were for orthodontic purposes). The study was exempted by a local ethical committee in the conservative Department, College of Dentistry, University of Basrah because it is an *in vitro* study. The collected teeth were of comparable size and dimension. To avoid bias that may result from the anatomical variation between samples, the bucco-palatal, mesio-distal widths (at the crest of curvature of each sample), and occluso-gingival height of each sample were gauged using a digital Vernier. A one-way analysis of variance (ANOVA) test was applied, and according to its result, the study was limited to 24 samples only. Only these samples showed a nonsignificant difference between their dimensions ($P \geq 0.05$). Thus, although the sample size was not too large, it would give us a more accurate result and reduce the standard deviation (SD). On the other hand, a small sample size had significantly reduced the cost and time required to conduct the study. The duration of the study was 4 months in 2020.

The teeth had been kept in deionized water to avoid dehydration throughout the study. All teeth had been mounted in auto-polymerizing acrylic material 2 mm apical to cemento-enamel junction (CEJ) to simulate the supporting alveolar bone level.[4]

All teeth had received full-crown preparation adhering to the guidelines of InCoris TZI-C recommendation (axial reduction, 1–1.5 mm; planner occlusal reduction, 4 mm occlusal-gingival height, chamfer finishing line [0.8 mm], and 1 mm above the CEJ).[12] To achieve the standardized preparation, an adjusted dental surveyor had been used to keep burs parallel to the tooth-long axis while preparing its axial walls.[13] This was to ensure a 6° overall taper for all teeth, which is the same taperness of the burs used in this study. A digital Vernia was used to check these dimensions.

All fabrication steps had been done according to manufacturer directions of the handled zirconia (InCoris TZI-C) and CAD-CAM operating system. A 3D digital model for each tooth had been captured using a digital intraoral scanner (Omnicam, Sirona, Germany).

Sirona in-Lab CAD SW 16.1 had been used to design the crown restoration. In the beginning, one crown had been fabricated; then, its morphology had been used as a reference to design all other restorations to gain more précised results.[14] The restoration parameter used in this study is that set by the CAD-CAM milling system manufacturer (InLab software 16.1). The teeth had been divided equally and randomly into three groups (of eight each) according to the cement-space thickness: group A = 80 µm, group B = 100 µm, and group C = 120 µm.

Each crown had been luted to its corresponding tooth using self-adhesive resin cement (RelyX unicem aplicap). Prior to the cementation, two coats of zircon primer (Z-prime plus) had been painted on the interior surface of each crown. This procedure had been carried out according to the manufacturer's instructions. A custom-made cementation device was used to hold each specimen and maintain a constant seating pressure parallel to the longitudinal axis of each tooth sample during the cementation course.[15] A 5-kg load (approximately 50N) had been applied to imitate the clinical situation, "biting force" during the cementation process.[16]

After the cementation, each specimen had been retained in distilled water for 7 days. The marginal fitness of each crown had been estimated by calibrating the vertical space in between the tooth finish line area and the crown margin, the specimens fixed in place using the same holding and cementation apparatus used earlier during cementation, and applying the same pressure to ensure the examination accuracy. The area of mid-lingual, mid-buccal, mid-distal, mid-mesial had been chosen to take the measurement. To gain more accurate results, each reading was repeated four times and their mean was taken. The measuring was undergone using a digital microscope (at 85× magnification power). The digital images had been taken and measured using IMAGE J software (v 1.32, Bethesda, USA) that calibrates the value in pixels. Each specimen had been inspected and captured at 85× magnification and calibrated using an image of a 1 mm increment taken at the same focal length and entered into IMAGE J by the option of set scale that converted all the calculated readings from pixels to micrometers (µm).

Statistical analysis

Data had been assembled and analyzed utilizing SPSS (version 24, USA). The following statistics had been used. Normality test was performed to estimate the normality of recorded data spreading, and Shapiro-Wilk test was done [Table 1]. It revealed normally distributed data (P value > 0.05).

Descriptive statistic was done including mean, SD, statistical tables [Table 2], and bar chart [Figure 1]. Inferential

Table 1: Testing the normality of distribution

Groups	Shapiro–Wilk			
	Statistic	df	*P value*	Significance
A	0.893	8	0.252	Nonsignificant
B	0.979		0.959	
C	0.841		0.077	

Table 2: Descriptive statistics of the marginal gap values of all groups calibrated in μm

Groups	No	Mean	± SD*	Minimum	Maximum	Significance (*P* value)
A	8	82.310[a]	2.147	79.466	85.145	0.000
B	8	75.682[b]	3.820	69.101	78.747	
C	8	64.832[c]	2.339	61.629	67.637	

[a]Group A, [b]Group B, [c]Group C

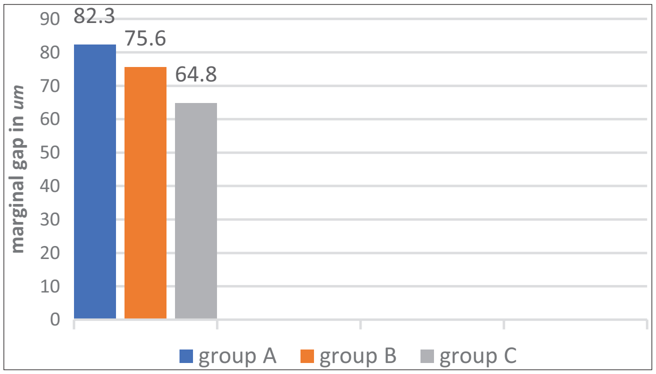

Figure 1: Bar chart showing the mean value of marginal gap of each group measured in μm

statistics includes one-way ANOVA and Tukey honestly significant difference (HSD) test to ascertain the presence of any significant differences between the means of groups (including the degree of freedom [df] and confidence interval). Significance had been determined by considering the $P \geq 0.05$ (nonsignificant) $0.05 \geq P > 0.01$ (significant), and $0.01 \geq P > 0.001$ (highly significant).

Results

Descriptive statistics of the marginal fitness in all groups are demonstrated in Table 2; the highest mean of marginal gap values (82.310 *μm*) was recorded for group A (which has the lowest cement-space thickness), as shown in the bar chart [Figure 1]. SD was applied to measure the variability in the results (SD < 3.9).

A one-way ANOVA test was applied to inspect if there is any statistically significant difference between groups. It showed a statistically highly significant difference among the three groups ($P < 0.01$). The df was applied to ensure the validity of the hypothesis (total df = 23).

Tukey-HSD test was applied to localize the source of the difference among the groups. It revealed that the application of 80 μm cement-space thickness had achieved a significantly higher means of marginal gap value than 100 μm and 120 μm groups ($P < 0.01$). Also, comparable results were observed when increasing cement-space thickness from 100 to 120 μm. Confidence intervals at 95% were applied to measure the degree of uncertainty in the sampling method.

Discussion

The goal of the current study was to assess the influence of three computer-aided cement-space thicknesses on the vertical marginal fit of monolithic zirconia crowns. Focusing on the vertical marginal gap because it is one of the most difficult errors to be corrected after crown fabrication has been completed, as indicated by Holmes *et al.*[17] Other discrepancies, such as restoration overhangs, can be altered to some extent intraorally, but the vertical marginal gap can only be sealed with luting cement, which is liable to disintegration.[6] For this reason, the vertical marginal gap has the greatest clinical significance and should be considered as the most critical step in the assessment of restoration margin.[18]

Crowns were designed with three different cement-space thicknesses using CAD software (80 *μ*m, 100 *μ*m, and 120 *μ*m). This comparison showed a statically highly significant difference in the values. The mean of the marginal gap was 82.3 μm (group A), 75.6 μm (group B), and 64.8 μm (group C). This indicates an increase in the cement-space thickness improves the marginal fit, as the cement-space thickness increased, the marginal gap reduced, and thus the hypothesis was rejected.[7]

Basically, crown-manufacturing procedures such as scanning, designing, and milling could affect the adaptation of the machined restoration,[19] which could result in internal inaccuracies and some premature contact at the tooth-restoration interface.[20] Furthermore, zirconia restoration milled in partially sintered status would go through (20%–30%) shrinkage in size in the course of the ultimate sintering stage[21]; this could cause some premature contact by the interface; therefore, the disappearance or reduction of these prematurities with increasing cement space might explain the result of this study, which was consistent with some previous studies[2,22-24]; they all noticed an improvement in marginal fit when increasing cement space. Hassan and Goo in 2021 stated that modifying cement space to 90 μm and 110 μm may improve the marginal adaptation of CAD/CAM crown.[23] Hammond and Ibraheem in 2020 assess that increasing cement space at the marginal area could reduce the degree of marginal opening; this might be as a result of the increased chance of excess cement escapement through the margin and might decrease the hydraulic pressure build-up within the internal surface of the crown, thus enhancing the adaptation of the monolithic restoration at the margin.[24] This finding can be clearly advocated when comparing marginal gap values of all groups as shown in Table 2.

The finding of the present study is in contrast with some previous studies[7,18,25]; they showed a nonsignificant effect on the marginal gap value when increasing the spacer settings. This might be due to the use of a different intraoral scanner, milling unit, convergence angle during sample preparation, crown cementation procedure, which cannot be entirely standardized, or it might be due to operator or technician influence.[7] Nevertheless, all the groups had a mean of marginal gap value within the clinically acceptable limit, which is 120 µm.[6,14,15]

Further research is needed to examine long-term water storage, thermo-cycling, different crown materials, and various luting cement types.

Conclusions

Within the limitation of the present study, it can be estimated that increasing cement-space thickness parameter can improve the marginal adaptation. Applying 120 μm space thickness might be favorable for a better adaptation of the monolithic crown restoration.

Within the limitation of the present study, 120 μm might be favorable for the adaptation of monolithic zirconia crown restoration.

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Conflicts of interest

There are no conflicts of interest.

Author contributions

FAT conceived the idea and literature search. ZMJ and HAH accomplished the data extraction. FAT and HAH revised the article.

Ethical policy and institutional review board statement

The study was exempted by a local ethical committee in the conservative department, College of Dentistry, University of Basrah, because it is an invitro study.

Patient declaration of consent

Not applicable.

Data availability statement

Data are available itself in the article.

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