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Evaluation of Post Cementation Marginal Seating of Monolithic Zirconia Crown Restorations Using Different Preparation Designs (A comparative *in vitro* study)

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Abstract

Objectives: The purpose of this in vitro study was to evaluate post-cementation vertical marginal seating of full contour zirconia crown restorations using different finish line designs (deep chamfer and shoulder) with different occlusal reduction schemes (planar and flat).

Materials and Method: Thirty-two sound maxillary first premolar teeth freshly extracted for orthodontic purposes were collected to be used in this study. Teeth were divided into two main groups according to the design of finishing line used (n=16): **Group A**: Deep chamfer; **Group B:** Shoulder. Each group was then subdivided into two subgroups according to the scheme of occlusal reduction used (n=8): **(A_1, B_1)** Planar; **(A_2, B_2)** Flat. Standardized preparation for full contour zirconia crown restorations was carried out with finishing lines depth 1.0 mm, total convergence angle of 6 degrees and axial height 4 mm (buccally and palatally).

Results: The results of this study showed that there were statistically highly significant differences among different groups ($p < 0.01$) using one-way ANOVA analysis and Student's t-test. Additionally, comparison of significance between each pair of subgroups at pre and post-cementation intervals using Paired-Samples t-test showed a statistically highly significant differences.

Conclusions: Deep chamfer with planar occlusal reduction scheme provided better marginal fit compared to that obtained with shoulder. On the other hand, shoulder with flat occlusal reduction scheme provided better marginal fit compared to that obtained with deep chamfer. Concerning the effect of the cementation procedure, the marginal gap was increased post-cementation as compared with the pre-cementation gap for all subgroups, but still within the clinically acceptable limit.

Key words: *Chamfer and shoulder finishing line, Digital impression, Full contour zirconia, Marginal fit, Planar and flat occlusal reduction scheme.*

Introduction

The success of all ceramic restorations strongly depends upon marginal adaptation. A well fitted margin is expected to reduce plaque accumulation, recurrent caries which result in damage to the tooth with its supporting periodontium, and potentially decreases the longevity of the restoration [(1)]. The clinically acceptable limit of the marginal discrepancies is reported to be less than 120 μm [(2)].

One of the CAD/CAM technology is a digital impression which provides speed, accuracy, high quality of restoration as its designing is based on materials characteristics, ability of storing captured information indefinitely and transferring digital images between the dental office and the laboratory [(3)].

The designs of tooth preparation can affect the success of the crown restoration [(4)]. Cementation of an indirect dental restoration is the final step after finishing all the clinical and laboratory stages and it is considered

to be an equally important stage that can affect the longevity of the restoration [5].

Materials and Method

Thirty-two sound human maxillary first premolar teeth of comparable size and shape extracted for orthodontic purposes were selected and collected to be used in this study.

The teeth samples were divided into two main groups according to the design of finishing line used (n=16):

Group A: Deep chamfer design.

Group B: Shoulder design.

Each main group was, then, subdivided into two subgroups according to the scheme of the occlusal surface reduction (n=8):

Subgroup A_1 & B_1: Anatomical occlusal reduction.

Subgroup A_2 & B_2: Non anatomical occlusal reduction.

All the teeth were prepared for full ceramic crown restorations with the following preparation features: A total convergence angle of 6 degrees, the depth for both deep chamfer and shoulder finishing line of 1.0 mm and a standardized axial height of 4 mm (buccally and palatally), these dimensions were checked using a modified digital caliper **(Fig. 1).**

After an axial reduction of each tooth according to its respective group, occlusal surface of all teeth was prepared with diamond wheel to produce flat occlusal reduction scheme. According to the scheme of occlusal surface reduction, all teeth samples in subgroups A_1 and B_1 received further occlusal reduction to change the design into planar using rugby ball bur. All sharp angles or internal line angles were rounded to prevent stress concentration on the crown restoration.

Figure 1:

A. **Deep chamfer finishing line with planar occlusal reduction scheme.**

B. **Shoulder finishing line with planar occlusal reduction scheme.**

C. **Deep chamfer finishing line with flat occlusal reduction scheme.**

D. **Shoulder finishing line with flat occlusal reduction scheme.**

A three dimensional digital image for each tooth sample was taken by AC Omnicam intra-oral scanner (Sirona Dental Systems, Bensheim, Germany) (powder free). Full contour zirconia crown restorations were then fabricated using In-Lab MC X5 milling device used (Sirona InCoris TZI C blank).

A custom made holding device was especially fabricated in this study to be used during seating of the zirconia crown, it serve as a screw that secured the zirconia crowns to the natural tooth sample. Furthermore, it hold the specimens on the horizontal table of the microscope to allow for viewing the references points during measurement of vertical marginal gaps **(Fig. 2)**.

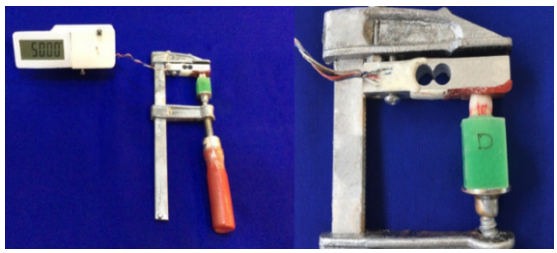
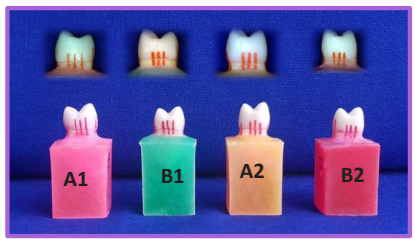


Figure 2: Zirconia crown on natural tooth sample secured with the specimen holding device.

Each zirconia crown was cemented on its respective tooth using Rely X U200 (3M ESPE, USA) self-adhesive resin cement. The cement was auto mixed and dispensed using disposable mixing tips supplied with the cement kit and applied directly as a thin even layer into the inner surface of the zirconia crown restoration. The crown was then seated on to its respective natural tooth with finger pressure initially then a static load of 5Kg was applied for 6 minutes according to the manufacturer's instructions using the specimen holding device **(Fig. 3)**.

Figure 3: The points of measurement on the surface of the tooth sample in each subgroup at a magnification of 50X.



The measurements were made at two intervals (before and after cementation) at four points determined

on each surface of the tooth (two at the edges of the line, two points drawn in the mid of the surface by permanent marker, while the other two points were at a distance of (1mm) from the previous one, on both (left and right sides). Sixteen measurements were obtained from each tooth sample; highest one was selected to represent the maximum marginal gap of that sample [6] **(Fig. 4)**.

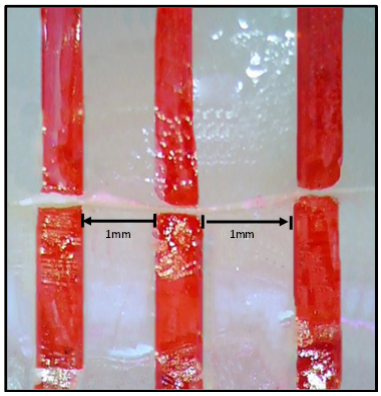


Figure 4: Four points of measurement at a magnification of 50X.

The measurement of the marginal gap of four different points at four areas (mid-buccal, mid-mesial, mid-distal and mid-palatal) was used by Khdaier and Ibraheem (2015) [7] and Abdulkareem and Ibraheem (2016) [8].

Statistical methods were used in order to analyze and assess the results included:

A- Descriptive statistic.

B- Inferential statistics.

1. One-way ANOVA (analysis of variance).

2. Paired-Samples t-test.

Results

Table (1) showed the descriptive statistics of vertical marginal gap for the four subgroups measured in µm at pre and post cementation intervals. At **Pre-cementation** interval, the table showed that the lowest mean of vertical marginal gap values was scored by subgroup **A_1 (38.837±9.30)**, while the highest mean of vertical marginal gap values was belonged to subgroup **B_1 (66.636±8.57)**, however on the other hand, at **Post-cementation** interval, the table showed that the lowest mean of vertical marginal gap values was scored by subgroup **A_1 (79.281±10.25)**, while the highest mean of vertical marginal gap values was belonged to subgroup **B_1 (110.082 ±9.63)**.

Paired-Samples t-test was applied in **(Fig. 5)**, showed that there was highly significant differences between the subgroups, this mean that cement have significant negative effect on the amount of vertical marginal gap of the crown restorations.

Table (1): Descriptive statistics of vertical marginal gaps for the four different subgroups in micrometer (pre and post-cementation)

Types of finishing line	Subgroups		Descriptive Statistics				
		Pre-cementation			Post-cementation		
		N	Mean	SD	Mean	SD	
Deep chamfer finishing Line	A	A_1	8	38.837	±9.30	79.281	±10.25
		A_2	8	63.199	±9.22	105.618	±10.11
Shoulder finishing Line	B	B_1	8	66.636	±8.57	110.082	±9.63
		B_2	8	50.763	±12.88	91.990	±14.02

HS: ($p < 0.01$) (Highly significant).

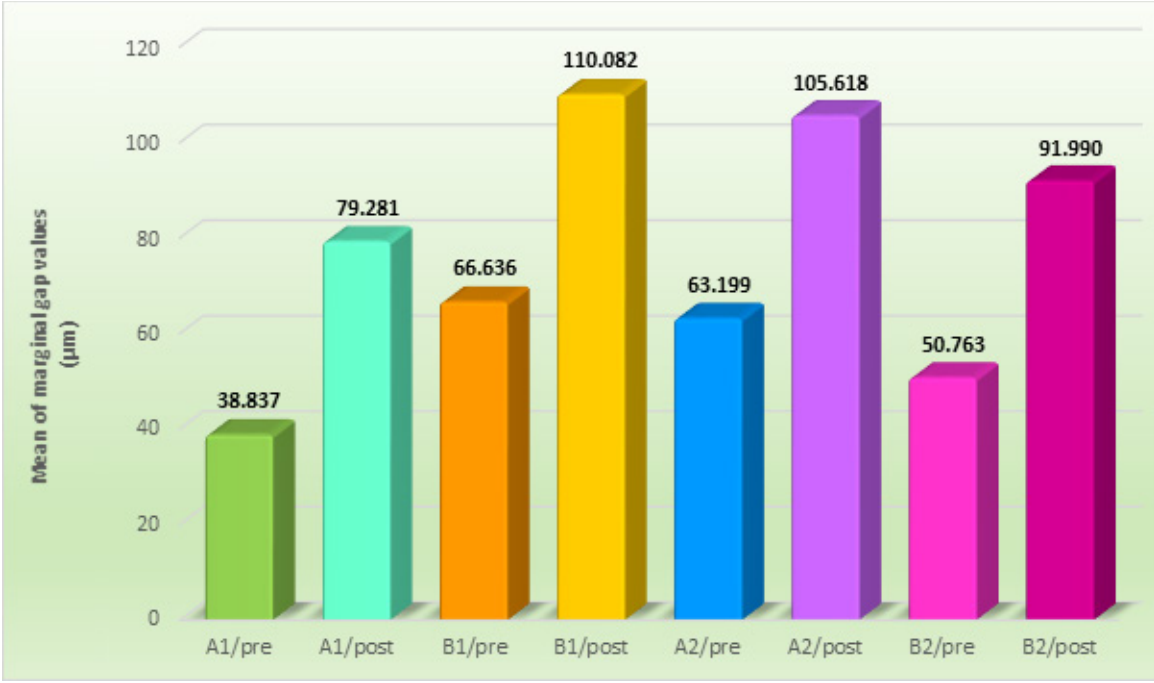


Figure 5: Bar-chart showing the mean values of the marginal gaps for all subgroups (pre- and post-cementation) in micrometer.

Discussion

The results of this in vitro study showed statistically highly significance difference but still within the clinically acceptable limit (<120 µm) for all tested subgroups. It is worth to mention that when reviewing the available literature, no previous studies concerning the effect of both finishing line designs with different occlusal reduction schemes on the marginal fit of full contour CAD/CAM zirconia crown restoration was found.

Statistical analysis of the results of this study showed that the teeth prepared with deep chamfer finishing line and planar occlusal reduction showed less mean marginal gap values than teeth prepared with flat occlusal reduction. This might be due to that the occluso-axial line angle is a right angle in the case of flat occlusal reduction scheme that may impende proper seating of the crown restoration.

However, the phenomenon was the opposite when the finishing line changed to the shoulder design where the mean marginal gap values of the teeth prepared with flat occlusal reduction was less than of that teeth prepared with planar occlusal reduction. This might be due to that the flat occlusal surface might produce smaller surface area than that produced with planar occlusal surface which might lead to even distribution of the load that going to be applied on the crown restoration during seating.

Furthermore, teeth prepared with shoulder finishing line and flat occlusal reduction showed less mean marginal gap values than the teeth prepared with deep chamfer finishing line. This might be due to that the force applied on the axio-gingival angle of the shoulder design was perpendicular on the surface of the margin, while in the chamfer design the force applied at the line angle of that surface was smaller and the applied pressure was thus smaller, so the seating of the crown restoration was not as good as in the shoulder design.

In addition to that, the teeth prepared with deep chamfer finishing line and planar occlusal reduction showed less mean marginal gap values than the teeth prepared with shoulder finishing line. This might be due to that deep chamfer finishing line design has a more round angle between the axial and gingival seat which enables more accurate seat for the crown restoration. Furthermore, the stress concentrated at the area of the finishing line during the crown seating is more evenly distributed. This is in total agreement with what has been stated by Rosenstiel *et al.* (2016) [9] stated that "The occluso-axial line angle of the tooth preparation should be a replica of the gingival margin geometry". In addition this is total agreement with: Wostmann *et*

al. (2005) [10] concluded that the lowest mean value of marginal gap was obtained for the chamfer preparation, while the 90° shoulder finishing line always produced the highest mean value. Comlekoglu *et al*. (2009) [11] reported that the cervical finish line type had an influence on the marginal adaptation of the tested zirconia crown restorations. This is also in agreement with Alzubaidy and Alshamaa (2015) [12] stated that the deep chamfer finishing line is more preferable than shoulder finishing line for full contour CAD/CAM zirconia crown restorations.

However, this disagrees Subasi *et al.* (2012) [13] revealed that the finish line design had no influence on the marginal adaptation of zirconia crown restorations.

On the other hand, the quality of the three dimensional image of a tooth preparation might be a factor that affect the marginal adaptation of the final crown restoration [14]. The scanning accuracy have the limitation of finite resolution; which can result in edges that are slightly rounded and leads to interfering contacts at the incisal/occlusal edges [15]. Furthermore, Reich *et al*. (2005) [16] reported the scanning system that depend on optical impression, experience problems with rounded edges and positive error (which simulates virtual peaks near the edges, so-called 'over-shooters'). The 'rounded edges', "point clouds" and 'over-shooters' phenomena have been described for the CEREC intraoral camera. In addition, the scanning process based on the principle of "not at the same plane surface" that is obtained in the scanning area were the scanning process transformed into smooth continuous surface [17].

Kunii *et al*. (2007) [18] reported the anisotropic shrinkage of zirconia blanks during construction procedure might play a role in the vertical marginal gap of different subgroups in this study, as a result, sintering shrinkage in the vertical axis was smaller than that in the horizontal axis due to this shrinkage property.

Effect of cement

The result of this *in vitro* study showed that the luting cement and cementation procedure play an important role in the final accuracy of the marginal fit for all ceramic crown restorations and this clearly shown when compare the result of pre-cementation with that recorded of post-cementation for all tested subgroups. Furthermore the statistical analysis of the results has proven the presence of those significant differences between each two subgroups at these two intervals.

The closing angle between tooth preparation and restoration becomes smaller, the flow of the cement is inhibited and its escapement becomes more difficult. Resin cement increased viscosity too rapidly to flow toward the cervical area and extruded from the margins of the crown, this will create the problematic discharge of excess cement and hydraulic pressure that is going to push the cement upward, this will result in great amount of luting cement to be accumulated on the occlusal surface of the prepared tooth that might interfere with proper seating of crown restoration after cementation procedure [19].

The luting cement and cementation procedure play an important role in the final accuracy of the marginal fit for all ceramic crown restorations, so, the marginal gap values were increased significantly post-cementation but within the limits of clinical acceptability (<120 μm), this is in total agreement with other previous studies: Okutan *et al*. (2006) [20].

Ethical Clearance: The Research Ethical Committee at scientific research by ethical approval of both environmental and health and higher education and scientific research ministries in Iraq

Conflict of Interest: The authors declare that they have no conflict of interest.

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