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An In–Vitro Comparative Study on the Marginal Adaptation of Metal Ceramic Crowns and Zirconium Dioxide Crowns with Rounded Shoulder Finish Line Preparation

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Abstract
Statement of Problem*.Although metal ceramic and zirconium dioxide restorations are widely used, there is a lack of information about how the fit is affected by fabrication procedures. The adequacy of the fit of all-ceramic restorations hasbeen questioned.*
Purpose*. This study examined the effect of porcelain and glaze firing cycles on the fit of metal ceramic and zirconium dioxidecrowns.*
Material and methods.*Fifteen standardized metal ceramic copings, zirconia copings and further crowns were fabricated on a metal die.A device was used to apply a uniform load on specimens during measurement and to reposition thespecimens on the measurement device after each manufacturing process. The specimens were not cemented andwere measured on the metal die using a stereomicroscope. Measurements were recorded at 18 points selectedalong horizontal and vertical planes. The crown systems were compared by use of the Student t test and 1-wayanalysis of variance (ANOVA). Analysis of Variance (ANOVA) and independent t-test were used for intra- and inter-group comparisons of marginal gap of metal copings, zirconia copings, porcelain fused to metal crowns and zirconia crowns.*
Results.*In this study mean marginal openings for conventionally fabricated metal copings was 18µm, for CAD/CAM fabricated zirconia copings was 10µm, for metal ceramic crowns was 20µm and for zirconia crowns it was 14µm respectively.The meanwise comparison of marginal gap of metal copings, zirconia copings and metal ceramic crowns, zirconia dioxide crowns were measured on all the surfaces. The mean difference obtained wasmaximum on mesial surface and minimum on the labial surface which was statistically significant as p value was< 0.05. No statistical difference was observed in zirconia copings and zirconia crowns.*
Conclusion.*Within the limitations of this study, it was concluded thatdistortion does occur in fixed prostheses during the porcelain firing cycle. Zirconia system showed significantly less distortion as compared to metal ceramic system. After veneering of zirconia copings marginal discrepancy was increased. Higher mean marginal gap was recorded in metal (Ni–Cr) copings and porcelain fused to metal crowns compared to zirconia copings and crowns. The difference in mean marginal gap between them was found to be statistically significant (p value <0.05).*

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I. Introduction

In the last decades, since the development of porcelain fused to metal procedures in the early sixties, metal ceramic restorations have represented the "gold standard" for years in prosthetic dentistry[1]. The following requirements should be fulfilled for successful porcelain fused to metal restorations,there should be accurate abutment castings and ease of casting, accurate soldering, rigidity of the metal frame, ability of the porcelain to fuse to metal, adequate strength of final restoration, esthetic tolerance, tissue tolerance and ease of repair[2]. Nevertheless, the investing procedures of wax patterns and casting procedures formetal alloys involve many technical variables and considerable number of operative steps and firing cycles, making the final quality of the restorations highly technique sensitive. Moreover, the metal framework and layer of opaque porcelain needed for masking underlying metal grayish shade lead to significant limitation for the esthetics[1.]

All these limitations of porcelain fused to metal restorations has forefront to the development of new all ceramic materials with superior mechanical properties such as high fracture toughness flexural strength, and

promising esthetic results. Besides, this lack of glass and dense polycrystalline microstructure provides resistance to hydrofatigue[3].

Inspite of type of material being used for the full crown restorations, one of the most important factor for their success is the marginal adaptation, which can be influenced by finish line design repeated ceramic firing cycles, and cementation materials[4]. Lack of adequate fit in crowns might affect fracture strength and thus reduces longevity, in addition to other known adverse effects of poor fit such as damage to the adjacent soft tissue leading to periodontal issues and caries near the margin[5]. Various values have been proposed in the literature as maximally acceptable marginal gap width. Some define clinically acceptable values for marginal gap after cementation should be smaller than 150µm. Others consider only marginal values of less than 120µm to be within clinically acceptable limit[6]. For CAD/CAM generated partially sintered zirconia could produce marginal values of 34-78µm.

While the all ceramic crowns have definite esthetic advantage over metal ceramic restorations this study aims to investigate and compare the marginal adaptation of all metal ceramic and zirconium crowns.

II. Material And Methods

The present study was undertaken with two different types of materials and they were divided into two groups named as group A and group B. Group A is further having a subgroup 'a' and Group B is further having a subgroup 'b'. Each group had fifteen samples so a total of thirty samples. Firstly, zirconia copings were fabricated followed by full crown fabrication similarly metal copings were made before full crown restorations and respective measurements were done on copings as well as on crowns.

The groups were as follows:

Group A: Zirconia crowns system.

Subgroup a : Preparation of zirconia coping.

Group B: Traditional PFM crown.

Subgroup b: Preparation of metal coping

An artificial mandibular molar (FRASECO Germani) was prepared for a complete crown restoration with a rounded shoulder finish line for both the groups. Preparations were performed with the following characteristics: anatomic occlusal reduction of 2mm, axial reduction of 1.0 to 1.5mm, and a rounded finish line located at the cementoenamel junction. The finish line for teeth in group A and group B was 1mm wide. Large round end tapered diamond burs (TR -21, Mani, Inc) were used. The evaluation of tooth preparation was done with the help of putty index and a Stainless steel crown gauge caliper D. A prepared mandibular molar (FRASECO German) is finally evaluated and the metal die is fabricated.[Figure 1]

Figure 1

Figure 2

A total of fifteen wax patterns were fabricated with a inlay wax(Bego Ref no-40111) on the fabricated metal die[Figure 2]. It was important that the copings be standardized so that no observed changes could be attributed to differences in contour, or thickness of the veneering area. To produce the coping wax patterns, dimensions were kept similar for all the copings i.e.0.5mm of occlusal and axial wall thickness with a 0.5mm approximately off the finish line. After the fabrication of wax patterns, the casting of copings would be done in a Ni-Cr base metal alloy. During all firing procedures, Opaque porcelain (VITA VMK 95) was applied to the copings to a thickness of approximately 0.5 mm. Zirconia copings and crowns were fabricated by CAD/CAM system, metal die was scanned by CAD scanner to obtain a virtual image[Figure 3] followed by fabrication with the CAD system. The zirconia copings(Cercon® ceram kiss DeguDent)was built-up incrementally to restore the final anatomical shape of the crown.

Figure 3

Figure 4

Copings and crowns were placed on metal die and stabilized with the help of C clamp,[Figure4] the marginal adaptation was then evaluated for all specimens with a stereomicroscope (Zoom Trinocular Stereomicroscope (Radical NSZT-44E) having 44xmagnification and a coupled digital camera (Nikon 4xzoom).Measurements were recorded at 18 points selectedalong horizontal and vertical planes.Finally, marginal discrepancy was measured with image analysis software (Medical Pro2.0).

III. Results And Observations

Descriptive statistics were performed to find out the marginal adaptation between different groups and subgroups. Analysis of Variance (ANOVA) and independent t-test were used for intra- and inter-group comparisons of marginal gap of metal copings, zirconia copings, porcelain fused to metal crowns and zirconia crowns. The level of significance for the present study was fixed at 0.05.

Table 1: Descriptive statistics of all the studied groups

Surface	Groups and subgroups	Mean	Std. Deviation	Std. Error Mean
Labial	Metal copings	4.5182171	7.2153038	1.8629834
	Zirconia copings	3.0201051	5.4180313	1.3989297
	Pfm crowns	5.9692981	14.2695226	3.6843749
	zirconia crowns	3.1325721	6.4711063	1.6708325
Mesial	Metal copings	4.3999051	12.2125337	3.1532626
	Zirconia copings	2.2356411	4.2870359	1.1069079
	Pfm crowns	4.7132991	6.6601537	1.7196443
	zirconia crowns	3.9031431	6.8608161	1.7714551
Distal	Metal copings	4.3281721	10.8370955	2.7981260
	Zirconia copings	2.3147811	5.4342220	1.4031101
	Pfm crowns	5.1664991	5.7395176	1.4819371
	zirconia crowns	3.3715351	5.7839717	1.4934151
Lingual	Metal copings	4.6553961	5.8950772	1.5221024
	Zirconia copings	2.6185421	4.0540886	1.0467612
	Pfm crowns	4.6863011	4.3517925	1.1236280
	zirconia crowns	3.2428761	7.1548123	1.8473646

Table shows the mean marginal gap, standard deviation and standard error of mean of respective groups and subgroups on each surface(labial, mesial, distal and lingual)of the metal die.

IV. Discussion

In this study, shoulder with rounded internal line angle configuration was used for finish line as it is well documented that this type of finish line shows the least stress concentration and significantly less distortion compare to other type of finish lines and is mostly recommended. A metal die was fabricated from the wax pattern and then casting was done in a cobalt chrome alloy such as to provide a definite reference that would not get damaged easily.[2]Final seating position of each crown specimen on the master die was stabilized by a C-clamp holding device such as to avoid displacement or seating error. As difference in accuracy of measurements for marginal gap was independent of weather the crown were cemented or notmeasurements were taken by seating the crown specimen without cementation. As this study attempt to evaluate the marginal opening of different materials at different phases of fabrication to obtain the relevant clinical information regarding marginal fit, therefore it is important to define the term used. In this study we have used the criterion, proposed by Homes et al. defining absolute marginal discrepancy which is defined as the distance from the edge of the crown to the edge of the finish line.[7]

In the current study, direct viewing technique was selected because it is a non-destructive, rapid, easy and convenient method and has been most frequently used to measure marginal discrepancy at various steps of fabrication techniques.[8,9] It has been reported that Scanning Electronic Microscopy (SEM) imaging was better than light microscopy to evaluate marginal gap of class II CAD/CAM inlays.[10] A wide range of values for measurements of marginal discrepancies is reported in the literature, ranging from 4µm to over 100 µm. However marginal gap value less than 50 µm is considered clinically acceptable for cast restorations[11,12,13] In this study mean marginal openings for metal copings was 18µm, for zirconia copings was 10µm, for metal ceramic crowns was 20µm and for zirconia crowns it was 14µm respectively as statistically described in Tables.

According to Campbell et al. greater distortion seen on the metal alloys due to release of stress during casting procedure, grinding and polishing phases. Additionally, significant increase in the marginal discrepancy was observed after firing the veneering porcelain which is in agreement with other studies mentioned in Table 4 and Table 3.[14,15,16,17] due to melting of porcelain particles causing contraction of the veneering porcelain and thus, compressive forces on the coping. Also distortion was greater on labial-lingually than mesio-distally due to distortion of the metal substructure.[4]Most distortion was observed after the degassing and glazing stages. These two stages have the highest firing temperatures, and both stages have a rapid descent of the frameworks out of the porcelain oven muffle.

In zirconia crowns, veneering porcelain harmonise by the manufacturer have coefficient of thermal expansion closer in value to zirconia frameworks, but any remaining difference between them lead to increase in marginal discrepancy after veneering of zirconia copings so metal copings and porcelain fused to metal crowns would have more marginal gap than zirconia copings and zirconia crowns. Another possible reason was previously reported [18] CAD/CAM machining of the presintered Y-TZP blocks induced microcracks at zirconia surface which cannot be completely eliminated by sintering. In the present study, the marginal distortion attributed during veneering of CAD/CAM zirconia frameworks to the low temperature aging phenomenon together with the mismatch between core and veneer coefficients of thermal expansion seems to be more reasonable factors rather than to the contraction forces developed from firing shrinkage of veneering porcelain because the high flexural strength and fracture toughness of zirconia can resist its deformation under contraction forces better than metal ceramic crowns. Hence, zirconia copings and crowns fabricated using CAD/CAM showed better marginal adaptation than Ni–Cr coping and porcelain fused to metal crowns fabricated using lost wax technique as statistically significant difference were found. Thus, the result of the study indicates that zirconia copings and crowns fabricated using CAD/CAM technology has better marginal adaptation than Ni–Cr coping and porcelain fused to metal crowns. Nevertheless, it must be noted that the marginal discrepancies of these crowns after porcelain veneering are still within the clinically acceptable standards and that the amount of distortion does not affect the clinical performance of the restoration.

V. Summary And Conclusion

Within the limitation of this study the following conclusion were drawn:

1.Distortion does occur in fixed partial prostheses during the porcelain firing cycle. This distortion was a result of changes in the metal as well as the contraction of fired porcelain.

2.Zirconia system showed significantly less distortion compared to metal ceramic systems.

3.After veneering of zirconia copings marginal discrepancy was increased due to the difference in the value of coefficient of thermal expansion of zirconia frameworks and veneering ceramic and also due to formation of microcracks at zirconia surface during CAD/CAM machining.

4.Higher mean marginal gap was recorded in metal (Ni–Cr) copings and porcelain fused to metal crowns compared to zirconia copings and crowns. The difference in mean marginal gap between them was found to be statistically significant (p value <0.05).

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