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Evaluation and Comparison of the Internal Fit and Marginal Accuracy of Base Metal (Nickelchromium) and Zirconia Copings Before and after Ceramic Veneering: A Sem Study

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Abstract - *This study compares the internal fit and marginal adaptation of copy milled Zirconia copings with Nickel-Chromium (Ni-Cr) copings fabricated using a lost wax technique before and after ceramic veneering. A standardized metal master die simulating a prepared crown was fabricated and twenty impressions of the metal die were made and poured with die stone. Wax patterns were made on ten dies and cast while light cure resin patterns were made on the other ten dies for copy milling the Zirconia copings. Five specimens from each group were subjected to ceramic veneering. All the test specimens were luted on to the fresh dies, embedded in dental plaster, sectioned and image analysis done using scanning electron microscopy. Thereafter statistical analysis is done using student t-test. The linear measurements for internal fit and marginal discrepancy were increased for Zirconia compared with Ni-Cr copings. The difference in the values of all the specimens of all the groups were not statistically significant ($P>0.05$) except the values comparing the internal fit of Zirconia and Ni-Cr copings before ceramic veneering ($P<0.001$) which was statistically significant. The internal fit and marginal adaptability of Ni-Cr copings were found to be better than the Copy milled Zirconia copings but internal fit and marginal adaptability deteriorated after ceramic veneering.*

KEYWORDS: Zirconia, Zirconia crowns, Marginal adaptability, Internal fit, Ceramic veneering.

INTRODUCTION

One of the important factors that ensure long-term success of fixed prosthodontics is the precision of the margins, which in turn forms an important indicator of the overall acceptability of a restoration. Lack of adequate fit is potentially detrimental to both the tooth and the supporting periodontal tissues[1]. Poor marginal adaptation of restorations increases plaque retention and changes the distribution of the microflora, which can induce the onset of periodontal disease[2]. It can also lead to microleakage under the restoration that can cause endodontic inflammation[3]. The fit of a crown is important, and many efforts have been made to reduce the distance between the prepared tooth and the crown margins[4]. Porcelain-fused-to-metal (PFM) crowns are produced with a variety of marginal designs to achieve the best fit and appearance[5]. PFM restorations are popular because of their durability and versatility, however, the major objection to the PFM crown is that the metal coping prevents the transmission of light. This limitation has encouraged research to explore construction of alternative metal free ceramics (all-ceramic crowns) [6].

With a growing awareness of aesthetics and biocompatibility, patients increasingly request metal-free solutions. Due to the successful use of all-ceramic crowns both in the anterior and posterior segments and with the introduction of advanced dental technology and high-strength ceramic materials, all-ceramic systems have become a viable treatment option in fixed prosthodontics. Such restorative all-ceramic systems must fulfil biomechanical requirements and provide longevity similar to metal-ceramic restorations while providing enhanced aesthetics [7].

Due to weak mechanical properties, most of these ceramics cannot be used for multiple-unit fixed partial dentures (FPDs). However, dense sintered 'high-tech' ceramic materials, e.g. tetragonal stabilized zirconia, possess best mechanical properties of all dental ceramics[8]. The use of zirconia ceramics for multiunit FPDs has been facilitated by the advent of Copy Milling and computer aided design/computer aided manufacturing (CAD/CAM) systems[7]. Compared to other core ceramics, Yttria stabilized tertragonal zirconia polycrystals (Y-TZP) ceramic demonstrates better mechanical properties and a superior resistance to fracture. The material has flexural strength of 900 to 1400 MPa, fracture toughness of up to 10 MPa/m0.5, and modulus of elasticity value of 210 GPa, making it an effective alternative to conventional PFM restorations[9].

Unfortunately the Metal and Zirconia[7] copings are subjected to marginal distortion during porcelain firing and various factors are considered responsible for this phenomenon[6]. Techniques and terminology describing and measuring fit of dental restorations vary considerably in the literature. There are different locations between a tooth and a restoration where the measurements can be made. According to Holmes *et al.*, the absolute marginal discrepancy is the best alternative to describe the fit. It represents the largest measurement of error at the margin and reflects the total misfit of the restoration at that point[10].

* MDS

A literature search revealed a limited number of studies evaluating the internal fit and marginal adaptation of Zirconia with Nickel-Chromium (Ni-Cr) copings. Hence this study compares the internal fit and marginal adaptation of Copy Milled Zirconia copings with Ni-Cr copings fabricated using lost wax technique before and after ceramic veneering.

METHOD

A standardized metal master die on a metal base simulating a prepared crown with chamfer finish lines was prepared with a triangular shaped orientation notch on the base on two opposite ends for the proper orientation of the special trays (Fig. 1).

A metal spacer with a uniform thickness of 0.5 mm was fabricated so that it fitted exactly over the die ensuring uniform thickness of the light body impression material during impression procedure.

Special trays [Autopolymerising PMMA Resin(DPI-RR Cold Cure, DPI, Mumbai)] with relief holes were fabricated and impressions made with Elastomeric impression material: Addition silicone (Aquasil, soft putty/ Regular set and light body, Dentsply). Twenty impressions were made using the same technique and twenty individual stone dies (Type IV (Ultrarock, Kalabhai) were fabricated. The specimens were divided into four groups and each group consisted of five specimens with a total of twenty dies.

GROUP 1- Consisted of Five dies numbered 1-5 on which the Ni Cr copings were fabricated using lost wax technique.

GROUP 2- Consisted of Five dies numbered 6-10 on which the Ni Cr copings were fabricated using lost wax technique and then veneered with ceramic.

GROUP 3- Consisted of Five dies numbered 11-15 on which the Zirconia copings were fabricated using Copy milling.

GROUP 4- Consisted of Five dies numbered 16-20 on which the Zirconia copings were fabricated using Copy milling and then veneered with ceramic.

For fabrication of Ni Cr copings (Wiron, Bego, Bremen, Germany) the wax patterns were made with Inlay wax [Type B (Bego crown wax; Bego Bremen, Germany)] and invested and casted.

For fabrication of Zirconia copings (Amann Girrbach, Germany), resin patterns were made using light cure modeling gel (ceramill gel, Amann Girrbach, Germany) and were then retrieved and mounted on the mounting template and fixed on to the ceramill base (Amann Girrbach, Germany) and copy milling carried out (Fig. 2). The pre sintered zirconia copings are then carefully separated from the mounting block by trimming it using a straight fissure bur and placed in the sintering furnace (Ceramill Therm, Amann Girrbach, Germany) for 8 hours.

Layering of the Ni Cr copings and Zirconia Copings were then carried with corresponding veneering ceramics to obtain uniform thickness of the veneering material on the copings by having the same ceramist veneer all the ten specimens. The copings and the crowns were luted on to the fresh dies using glass ionomer cement under a uniform load of 5kg using the jig. The specimens were then embedded in the plaster and sectioned along the long axis diagonally using a diamond disk (Fig. 3). Sectioned dies are then subjected for scanning

Figure 1. *Special tray used for impression making*

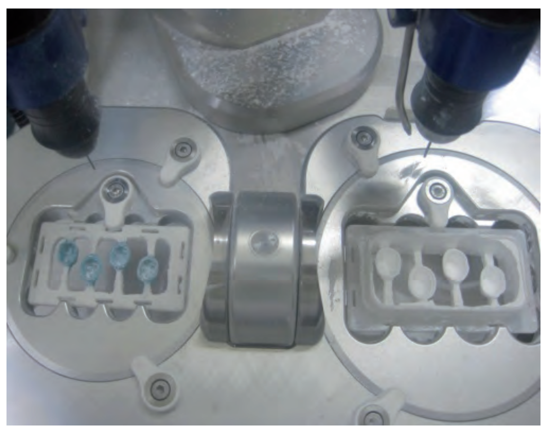


Figure 2. *Copy milling of the zirconia specimens*

Figure 3. *Sectioned specimens*

and image analysis using scanning electron microscope and marginal discrepancies were measured with the help of the soft ware SCANPRO (Fig. 4). For measurement and analysis, Point A and B were considered at the level axioincisal line angles to measure internal fit and Point C and D were considered at the level of finish lines to measure the marginal discrepancy on the sectioned die (Fig. 5).

The values were then tabulated and mean, standard deviation calculated for internal fit and marginal discrepancy of all four groups. The results then subjected to statistical analysis using student t-test.

RESULTS

The values recorded at point A, B C, D were tabulated and the mean and standard deviations of each point calculated. These values were then compared within the groups to compare the fit between the materials and to evaluate the change in the fit after ceramic veneering.

Further the mean of Point A and Point B was calculated which reflected the internal fit (TABLE I) and the mean of Point C and Point D which reflected the marginal adaptability (TABLE II) of the particular specimen in microns.

While comparing the internal fit and marginal adaptability between Ni-Cr copings and zirconia copings, it was found that the linear measurements for internal fit and marginal discrepancy was more for copy milled zirconia copings as opposed to Ni-Cr copings. The fit of Ni-Cr and zirconia copings deteriorated after ceramic veneering except the marginal adaptability of zirconia copings which was unusually found to improve after ceramic veneering.

The difference in mean internal fit was not found to be significant between Group 1 & Group 2 ($P>0.05$) i.e. before and after veneering of Ni-Cr copings, between Group 2 & Group 4 ($P>0.05$) i.e. between Ni-Cr and Zirconia copings after veneering as well as between Group 3 & Group 4 ($P>0.05$) i.e. before and after veneering of Zirconia copings. However, the difference in mean internal fit was found to be statistically significant between Group 1 & Group 3 ($P<0.001$) i.e. between Ni-Cr and Zirconia copings before veneering.

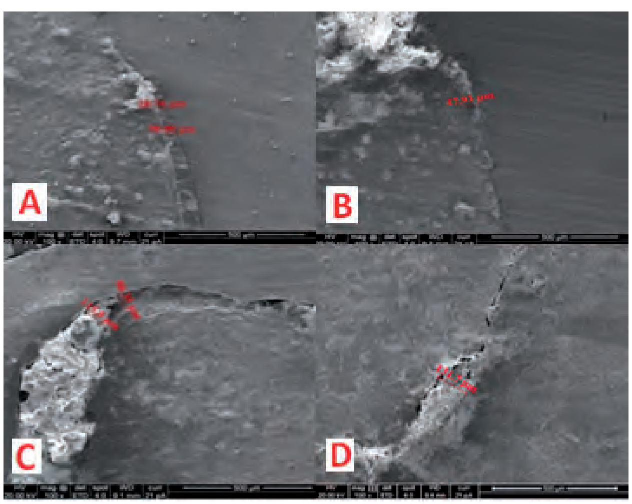
The difference in mean marginal adaptability was not found to be significant between Group 1 & Group 2 ($P>0.05$) i.e. before and after veneering of Ni-Cr copings, between Group 3 & Group 4 ($P>0.05$) i.e. before and after veneering of Zirconia copings, between Group 2 & Group 4 ($P>0.05$) i.e. between Ni-Cr and Zirconia copings after veneering as well as between Group 1 & Group 3 ($P>0.05$) i.e. between Ni-Cr and Zirconia copings before veneering.

Figure 6,7 represents the graphical comparison of internal fit and marginal adaptability of various groups

DISCUSSION

Porcelain fused to metal restorations are commonly used in fixed prosthodontics because of their casting accuracy, the high strength properties of the metal, and their wide acceptance[2]. Over the last 3 decades, interest in more esthetically pleasing and metal-free restorations has increased the demand for all-ceramic restorations, and several systems are currently available[3]. Based on these excellent physical properties, zirconia has been advocated as framework material for all-ceramic FPDs[6]. Although currently Y-TZP material is being proven as a core material for complete-coverage restorations such as all-ceramic crowns and all-ceramic FPDs, its fit is not proven beyond doubt[5]. The fit of all-ceramic restorations was investigated by several authors, and the mean marginal discrepancy range was reported as 19 to 160 µm[11].

This study evaluated the internal fit and marginal adaptation of copy milled Zirconia copings with that of Ni Cr copings fabricated using lost wax technique before and after ceramic veneering. Results indicate that Ni Cr copings had better fit than Zirconia copings. The above results were similar to the



A: Ni-Cr coping cefore veneering; **B**: Ni-Cr coping after veneering

C: Zirconia voping before veneering; **D:** Zirconia coping after ceneering

Figure 4. *Scanning electron micrograph showing points of measurement in various groups of specimens*

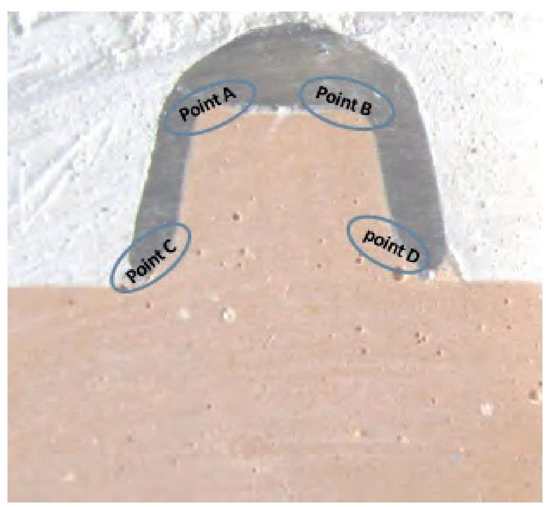


Figure 5. *Point a,b,c,d measured in the specimen for checking the internal fit and marginal discrepancy*

Table I: *Comparison of internal fit (point a& point b combined)*

Group	Mean	Std dev	Mean difference	t	P-value
Group 1	124.44	19.26	-37.588	-1.464	0.203
Group 2	162.03	54.07			
Group 1	124.44	19.26	-65.652	-5.728	<0.001*
Group 3	190.09	16.91			
Group 2	162.03	54.07	-85.510	-1692	0.129
Group 4	242.54	91.67			
Group 3	190.09	16.91	-52.446	-1.258	0.244
Group 4	242.54	91.67			

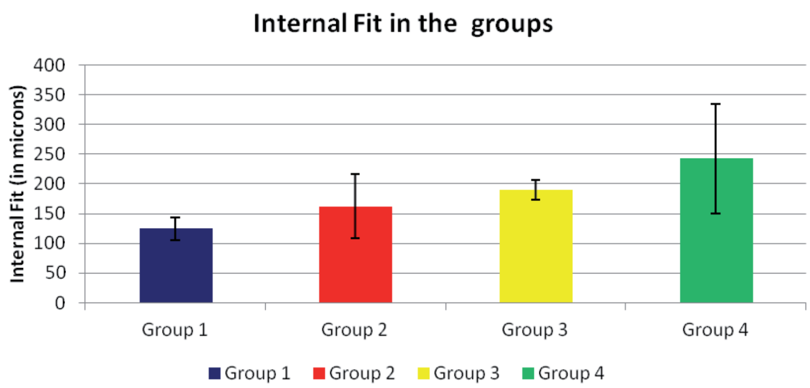
**denotes significant difference*

The difference in mean internal fit was not found to be significant between Group 1 & Group 2 (P>0.05), Group 2 & Group 4 (P>0.05) as well as between Group 3 & Group 4 (P>0.05). However, the difference in mean internal fit was found to be statistically significant between Group 1 & Group 3 (P<0.001).

Table II: *Comparison of marginal adaptability (point c & point d combined)*

Group	Mean	Std dev	Mean difference	t	P-value
Group 1	204.48	46.99	-0.752	-0.024	0.981
Group 2	205.24	51.76			
Group 1	204.48	46.99	-70.314	-3.070	0.015
Group 3	274.80	20.35			
Group 2	205.24	51.76	-33.106	-0.974	0.359
Group 4	238.34	55.67			
Group 3	274.80	20.35	36.456	1.375	0.206
Group 4	238.34	55.67			

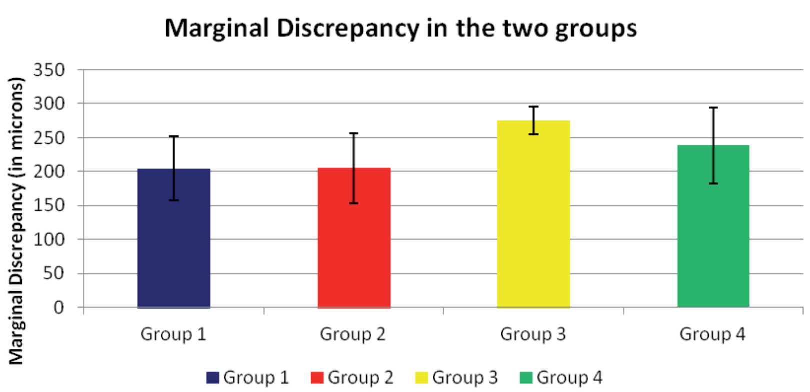
The difference in mean marginal discrepancy was not found to be significant between Group 1 & Group 2 (P>0.05), Group 1 & Group 3 (P>0.05), Group 2 & Group 4 (P>0.05) as well as between Group 3 & Group 4 (P>0.05).



Group 1 - (Ni-Cr coping before veneering), Group 2 - (Ni-Cr coping after veneering)

Group 3 - (Zirconia coping before veneering), Group 4 - (Zirconia coping after veneering)

Figure 6. *Internal fit in the groups (in microns)*



Group 1 - (Ni-Cr coping before veneering), Group 2 - (Ni-Cr coping after veneering)

Group 3 - (Zirconia coping before veneering), Group 4 - (Zirconia coping after veneering)

Figure 7. *Marginal adaptability in the groups (in microns)*

results obtained in studies conducted by Wettstein F *et al* [6], Bindl et al[12] and Reich et al[13] in their studies. This increase in the measurements for Zirconia frameworks may be attributed to the CAM system (Copy milling) that is employed in this study. Other reason for increase in the measurements for Zirconia frameworks may be attributed to the use of Pre sintered blocks in this study[14]. In contrast to the findings of this study, Gonzalo *et al* reported in his study that the accuracy of fit achieved for the 3 zirconium oxide groups were better than in the metal ceramic group[15]. Similar conclusions were drawn by Abbate et al[16], Valderrama S et al[17] and Persson et al[18] in their studies comparing fit of Zirconia ceramic with that of metal ceramic groups. The reason for the above findings in these studies may be because they used CAD/CAM for milling the frameworks as opposed to CAM only system (Copy milling) used in the present study.

Deterioration of fit of Ni Cr copings after ceramic veneering, found in the present study was in accordance with the study conducted by Bridger et al[19], Castellani et al[20] and Oruc et al[21]. Different factors are considered responsible for this phenomenon: (1) shrinkage of porcelain with warpage of the copings, (2) interfacial shear stress between copings and veneering porcelain, (3) grain growth or contaminated coping that creates a reduced orifice and prevents complete seating, and (4) porcelain contamination of the internal surface of the coping[6].

The deteriorating fit of Copy milled Zirconia copings before and after ceramic veneering, were not in accordance with the results of the study conducted by Vigolo et al[22] and Shearer et al[23] in which they concluded that the porcelain firing cycles and the glaze cycles did not affect the internal fit of the zirconium-oxide-based ceramic systems. However studies by Att et al[24], Dittmer et al[25] and Kohorst et al[26] demonstrated that veneering procedures may have a significant influence on the marginal adaptation of zirconia-based restorations. The authors concluded that Zirconia copings were also not completely stable during the porcelain firing cycle and that the distortion that occurred might have been due to non uniform porcelain mass.

The difference in the internal fit of Copy milled Zirconia copings following ceramic veneering in the present study may be explained by the fact that during the porcelain veneering procedure, particles of porcelains melt and gather to fill up voids and the resulting contraction of the porcelain mass causes a compressive force on the coping. The deformation of the coping under the stress of contracting porcelain is spread around the whole circumference of the margin. Nevertheless, it must be noted that the marginal openings of these crowns after the porcelain veneering were within clinically acceptable standards and that the amount of distortion suggests no inferences to the detriment of clinical application.

CONCLUSION

The internal fit and marginal adaptability of Ni-Cr copings were found to be better than the Copy milled Zirconia copings but internal fit and marginal adaptability deteriorated after ceramic veneering.

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