IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Effect of layering ceramic on marginal fit of zirconia crowns – An in vitro study

Dr. Mohammed Abdul Quadir

Prosthodontist and Implantologist
Department of Prosthodontics,
DrMAQ Dental Hospital, Hyderabad, India

Abstract:

Objective: This study evaluated the marginal fit of CAD/CAM copings milled from Cercon HT blocks. It also evaluated the effect of firing on the marginal fit of zirconia copings.

Materials and method: A stainless steel master die was fabricated using CNC-lathe of dimensions with crown length of 6mm, width of 7mm having 1mm rounded shoulder finish line with 50 taper on each side with occlusal diameter of 5mm. It also had a orientation groove of 0.5mm. Impressions were made and were poured in type IV die stone. Each die was scanned with a Dentsply Sirona inEos X5 scanner to produce the copings. The copings were seated on the master die with approx. load of 50N. A stereomicroscope was used for direct viewing of the marginal gap. Image analysis software was used to measure the marginal gaps in micrometers. For zirconia copings the measurements for marginal gap were made before and after firing. Data was analyzed by paired t-test.

Results: There was no significant difference between marginal fit of zirconia copings before and after porcelain firing ($p<0.05$).

Conclusion: The marginal fit of the copings before ceramic firing was lesser than marginal fit after ceramic firing, but the difference between the two margins after firing was not significant. Both marginal configurations showed marginal gaps that were within a reported clinically acceptable range of marginal discrepancy**.**

I. INTRODUCTION

Current trends in dentistry have seen higher demands for metal free restoration materials. Due to the increasing demands for esthetic restorations and biocompatibility concerns, all ceramic restorations have been widely used in the last few decades[1]. Recently, the use of computer-aided design/computer-aided manufacturing (CAD/CAM) systems for producing all ceramic restorations has been growing rapidly. Use of yttria-stabilized tetragonal zirconia polycrystalline (Y-TZP) for fabrication of all ceramic frameworks by means of CAD/CAM is common due to its unique characteristics including excellent biocompatibility, low plaque accumulation and unsurpassed mechanical properties[2].

The excellent aesthetics of the restorations is accomplished by application and successive sintering of translucent veneering dentin and enamel porcelains onto the white or even tooth-coloured zirconia core. This veneering process may influence the fitting accuracy of the whole restoration because of thermal distortions of the core. Distortion of marginal fit could be due to the shrinkage of porcelain as a result of coping distortion, CTE incompatibility of the core and the veneering porcelain, and porcelain contamination of the internal surface of the copings. In addition to aesthetics, strength, and biocompatibility, marginal accuracy is one of the fundamental requirements for clinical assessment and success of dental restorations[3]. Inaccurate marginal fit causes a space between restoration and prepared tooth, which accelerates the dissolution of luting agent[4]. Subsequently, oral bacteria and food debris accumulate in this space, leading to secondary caries, pulpal lesions, postoperative sensitivity, periodontal disease and marginal discoloration leading to failure of the prosthesis[5-8].

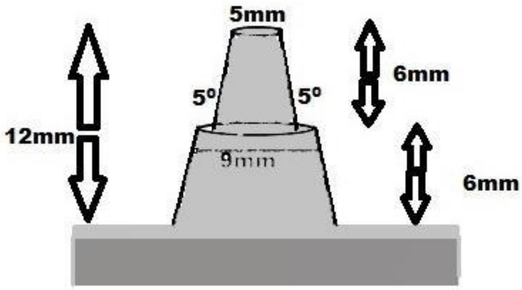
According to McLean and von Fraunhofer[9], the maximum acceptable marginal opening is 120 µm. The mean marginal discrepancy for all ceramic restorations reported in former studies was between 3.7 µm to 174 µm; and the majority of the reported values were less than or equal to 120 µm[10]. In CAD/CAM restorations, it is claimed that due to the reduction in human errors and material imperfections, minimal acceptable marginal gap was less than 100 µm[11]. A wide range of variables can affect the marginal accuracy of CAD/CAM restorations such as; the scanning process, software design, milling and thermal distortion during final firing of the restoration.[12,13]

II. MATERIALS AND METHOD

2.1 Fabrication of master die

A stainless steel master die (fig.1) was fabricated which had a platform for the base of dimensions 40x40mm (fig.2). It also had a crown length of 6mm, width of 7mm having 1mm rounded shoulder finish line with 50 taper on each side with occlusal diameter of 5mm. It also had an orientation groove of 0.5mm on the axial wall to lock the copings against rotation.

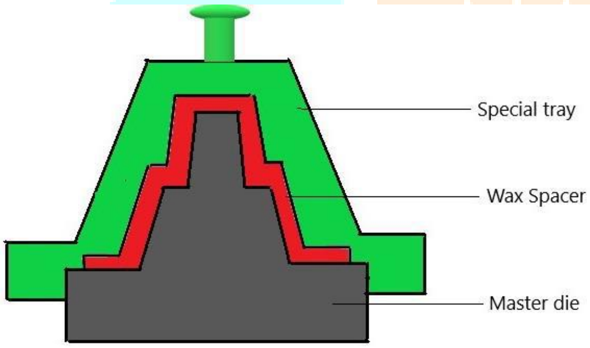
(Fig.1) Staiinless steel master die



(Fig.2) Dimensions of mater

2.2 Fabrication of customized tray and Duplication of the master model

A wax spacer (fig.3) of 3mm thickness was adapted over the model till short of 1mm from the borders of the customized tray. A customized tray (fig. 3 & 4) was fabricated using picca tray material over the spacer. Escape holes were made with the round bur no. 6 followed by the application of tray adhesive to the internal surface and was left for 5 minutes. The regular body (Aquasil ultra) (fig. 5) was loaded in the tray and was placed over the master die with a finger load of approx. 50N. After the setting of the impression material, the tray was removed and 30 casts were poured in Type IV die stone (Kalabhai Kalrock) with W/P ratio of 100:18.6 after 12 hrs.



(Fig. 3) Schematic representation of master model and spacer design

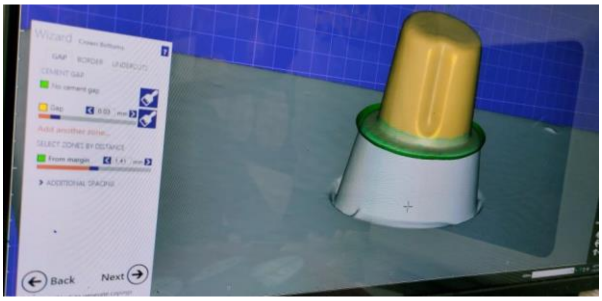
(Fig. 4) Customized trays

(Fig.5) Regular body impressions

2.3 Milling of Zirconia copings

The stone dies (fig. 6) were shipped to the laboratory for the fabrication of 30 zirconia copings (n=30). Each die was scanned (fig. 7) with a Dentsply Sirona inEos X5 following the manufacturer's instructions to record the external die form. The CAD design system was used to locate the margin, the die spacer thickness was set to 25μm which was uniform throughout and terminated 1.4 mm from the finish line. Vent holes were made over the occlusal suface of the zirconia copings (n=30) in order to reduce the hydrostatic pressure created by the fit checker at the intaglio surface of crown and therefore improves the overall fit of the crown (Sallustio et al., 1992; Clark et al., 1995; Lindquist and Connolly, 2001). A new set of burs (Sirona CEREC/inlab step bur 10 and Cylinder pointed bur) were inserted into CEREC inlab 3 milling unit (Sirona) for milling of the 30 specimens. All the samples (fig. 8) were designed and milled under the supervision of one operator assisted by one lab technician. The water supply was changed according to the software's notification. All samples were steam cleaned to remove any milling residue from the intaglio of the copings after the milling process.

(Fig. 6) Die stone models



(Fig.7) Designing of the coping

(Fig.8) Milled zirconia copings

2.4 Evaluation of marginal of discrepancy

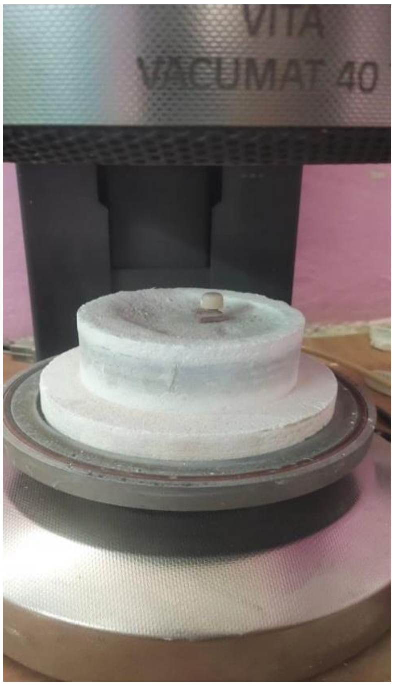
The obtained zirconia copings (n=30) were filled with the fit checker II (GC) (fig. 9) and were pressed over the master die with approx. finger load of 50N until it was polymerized. The copings (n=30) were gently removed from the master die. Polyvinyl siloxane (Aqausil) impression material was injected on the internal surface of the coping to stabilize the thin layer of fit checker II. The obtained specimens (n=30) were embedded in the paraffin wax (fig. 10) blocks and the slicing of the specimens was done with the microtome (LEICA RM 2125RT). The specimens were viewed under 40x magnification in the stereomicroscope. The images were obtained by microscope digital camera (Amscope) and the measurements were made.

(Fig. 9) Application of fit checker II (GC)

(Fig.10) Sectioned silicon replica

2.5 Ceramic firing on the zirconia copings

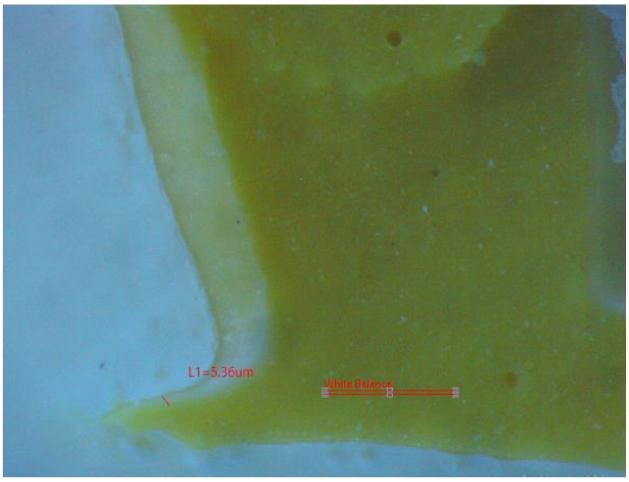
The zirconia copings (n=30) were veneered with the ceramic (VITA) (fig. 11) and were filled with fit checker II (GC). The zirconia copings (n=30) were then pressed over the master die with an approx. finger load of 50N until it polymerizes. The copings were then removed from the master die. Polyvinyl siloxane (Aqausil) impression material was injected on the internal surface of the coping to stabilize the thin layer of fit checker II.

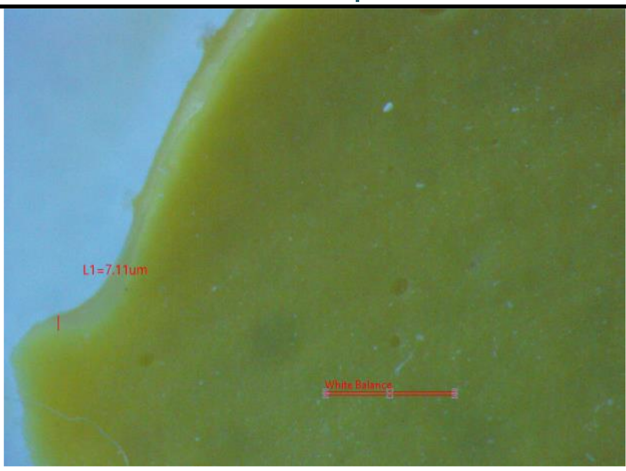


(Fig.11) Ceramic veneering on zirconia copings

The obtained specimens (n=30) were embedded in the paraffin wax (fig. 12) blocks and the slicing of the specimen was done with the microtome (LEICA RM 2125RT) and was viewed under 40x magnification under the stereomicroscope. The images were obtained by microscope digital camera (Amscope) and the measurements were made.

(Fig.12) Silicon replicas embedded in paraffin wax





(Fig.13) Microscopic images of the sectioned sample

III. RESULTS

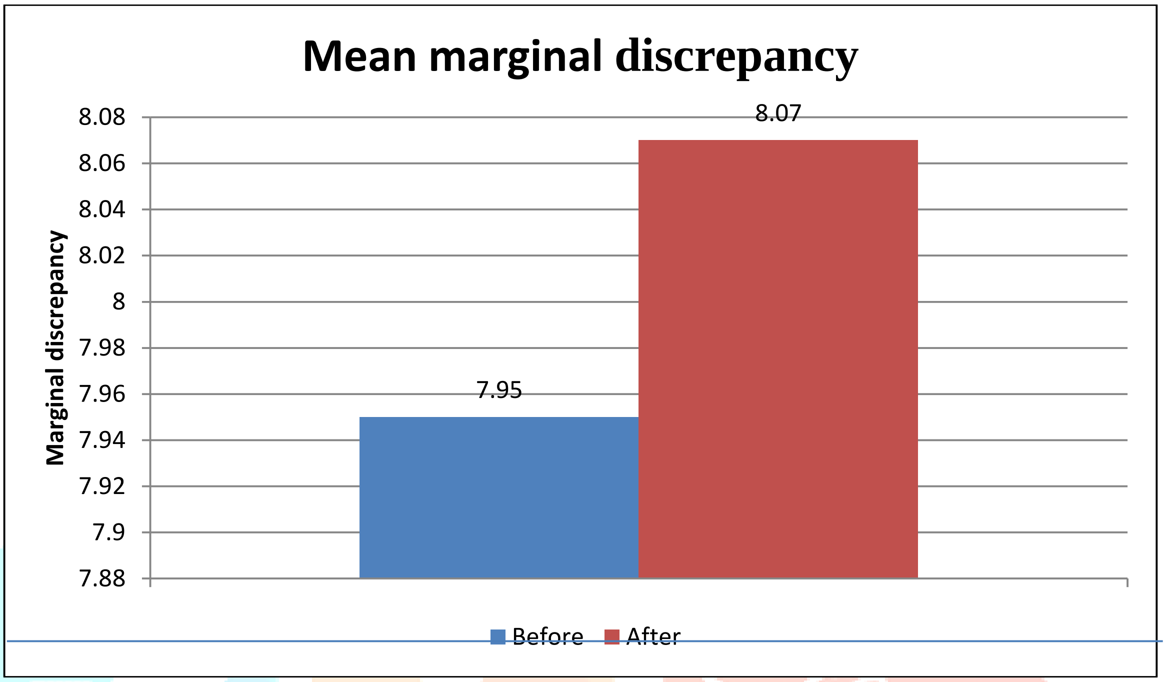
For measuring the marginal discrepancy of zirconia crowns, all 30 samples were sectioned using silicon replica technique and were measured in stereomicroscope via photographic analysis software (Amscope). The data obtained was tabulated (Table 1) and subjected to statistical analysis.

Table 1. Marginal discrepancy before ceramic firing & after ceramic firing

S.No.	Before firing(µm)	Mean	S.No.	After firing(µm)	Mean
Sample 1	8.31µm		Sample 1	9.48µm	
Sample 2	3.86µm		Sample 2	5.94µm	
Sample 3	9.50µm		Sample 3	8.89µm	
Sample 4	8.94µm		Sample 4	7.45µm	
Sample 5	13.03µm		Sample 5	12.92µm	
Sample 6	7.18µm		Sample 6	8.42µm	
Sample 7	8.68µm	7.95 µm	Sample 7	7.93µm	8.07 µm
Sample 8	6.69µm		Sample 8	7.42µm	
Sample 9	5.68µm		Sample 9	6.51µm	
Sample 10	6.96µm		Sample 10	6.98µm	
Sample 11	4.27µm		Sample 11	4.52µm	
Sample 12	12.07µm		Sample 12	11.83µm	
Sample 13	9.32µm		Sample 13	9.65µm	
Sample 14	3.55µm		Sample 14	4.75µm	
Sample 15	10.11µm		Sample 15	9.64µm	
Sample 16	5.36µm		Sample 16	5.87µm	
Sample 17	7.11µm		Sample 17	7.11µm	
Sample 18	5.60µm		Sample 18	5.88µm	
Sample 19	5.67µm		Sample 19	6.13µm	
Sample 20	10.72µm		Sample 20	10.81µm	
Sample 21	9.05µm		Sample 21	8.95µm	
Sample 22	11.84µm		Sample 22	11.21µm	
Sample 23	6.18µm		Sample 23	6.93µm	
Sample 24	13.63µm		Sample 24	12.39µm	
Sample 25	5.04µm		Sample 25	4.87µm	
Sample 26	13.37µm		Sample 26	12.82µm	
Sample 27	5.02µm		Sample 27	5.42µm	
Sample 28	8.04µm		Sample 28	8.65µm	
Sample 29	7.41µm		Sample 29	7.49µm	
Sample 30	6.55µm		Sample 30	7.02µm	

The table (table 1) shows the marginal discrepancy of zirconia crowns **before ceramic firing**. The highest discrepancy recorded was **13.63µm** and the lowest recorded was 3.55µm. The mean marginal discrepancy obtained is **7.95 µm.**

Marginal discrepancy after ceramic firing: The highest discrepancy recorded was **12.92µm** and the lowest recorded was 4.75µm.



Graph 1: Showing mean marginal discrepancy before and after ceramic firing

From the above graph, it can be interpreted that mean marginal discrepancy before ceramic firing is **7.95µm** and after ceramic firing is **8.07µm.**

3.1 Statistical analysis

Tests of Normality

The following data was established to determine its normality by using Kolmogorov-Smirnov test and Shapiro-Wilk test (Table 2).

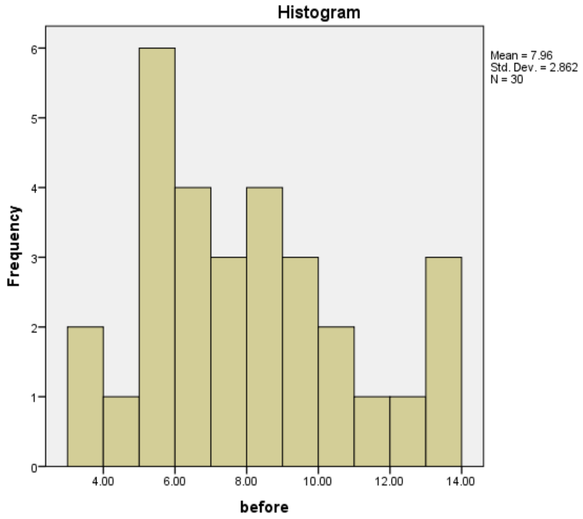
Table 2 Tests of Normality

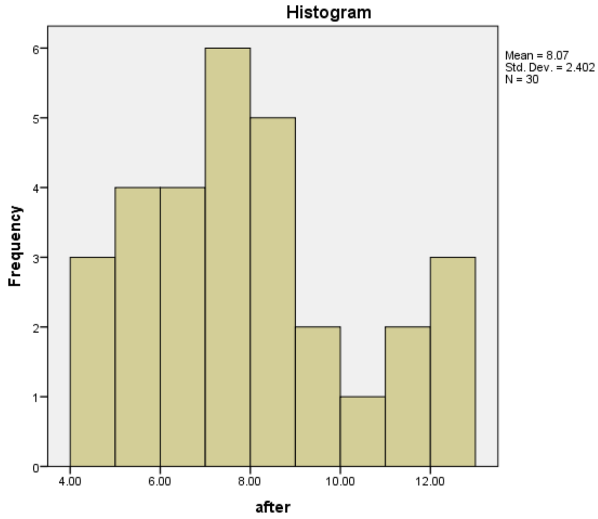
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Before	.109	30	.200*	.952	30	.189
After	.129	30	.200*	.943	30	.110

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results were insignificant which indicates that the data is normally distributed.





Graph 2 and 3: Showing standard deviaton of 2.862 before ceramic firing and 2.402 after ceramic firing

Statistical analysis (table 3) was done using IBM SPSS Statistics 20. Descriptive statistics, paired t-test was performed. P value < 0.05 was considered statistically significant.

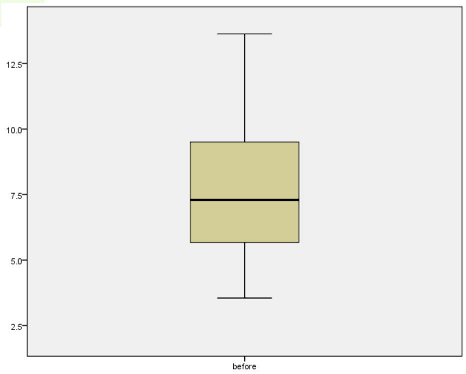
Table 3

Group	**Mean**	**Std. Dev**	**P-value**	**Sig**
Before	7.95	2.86	0.43	NS
After	8.07	2.40		

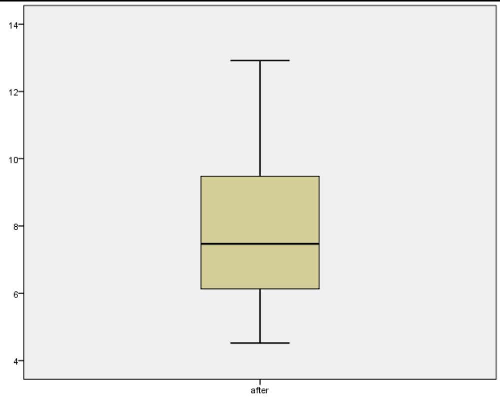
From the above data it can be interpreted that the highest marginal discrepancy before ceramic firing was **13.63µm** and the lowest recorded was **3.55µm.** The mean marginal discrepancy obtained was **7.95 µm.**

The highest marginal discrepancy after ceramic firing was **12.92µm** and the lowest recorded was **4.75µm.** The mean marginal discrepancy obtained was **8.07 µm.**

A paired t test was performed to compare the mean marginal adaptation of zirconia crowns before ceramic firing and after ceramic firing.



Box chart 1: Shows marginal discrepancy with a mean of 7.96µm and a standard deviation of 2.862 before ceramic firing.



Box chart 2: Shows marginal discrepancy with a mean of 8.07µm and a standard deviation of 2.402 after ceramic firing.

The marginal fit of the copings before ceramic firing was lesser than marginal fit after ceramic firing, but the difference between the two margins after firing was not significant. These findings suggest that ceramic firing cycles change the marginal fit of the copings. As there was no significant difference between the zirconia copings before and after ceramic firing, clinically it does not change things much.

IV. DISCUSSION

The precision of fixed prosthodontic restorations depends mainly on accuracy during die fabrication which in turn is directly dependent on the quality of the impression and working cast. Fit[13] has been defined in both *in vitro* and *in vivo* studies as the marginal discrepancy. This gap is important because the amount of space will determine the amount of possible cement dissolution. **Holmes et al.[14]** defined the internal gap as the measurement between the axial wall of the prepared tooth and the internal surface of the casting, while the same measurement at the margin is called "marginal gap". Furthermore, an angular combination of marginal gap and extension error is an "absolute marginal discrepancy" which specifically defines the linear distance from the surface finish line of the preparation to the margin of the restoration. Little information is available on the clinical relevance of gap sizes on crowns. No general guidelines exist on how to perform gap measurements on crowns in vitro or in vivo. The null hypothesis was that marginal discrepancy of zirconia crowns would not be affected by ceramic firing which was **in accordance** with **Mahroo Vojdani et al[15]** who stated that no differences would be found in the marginal fit of zirconia CAD/CAM crowns before and after porcelain firing.

Recent advances in dental computer-aided design/ computer-aided manufacturing (CAD/CAM) systems have allowed the development of all-ceramic systems using zirconia and have enabled all-ceramic restorations of the molar region. The Cercon® Smart Ceramics System used in this study is an all-ceramic system. The Cercon® Smart Ceramics System includes a core of zirconia on which a layering of porcelain material is built up to complete the prosthesis for crown restoration.

In this study marginal fit of zirconia crowns was evaluated before and after ceramic firing. A standardized master stainless steel die was designed and fabricated using CNC-lathe. Several studies have used master metal dies. The advantages of using a master metal die are a standard preparation, as well as wear resistance during fabrication procedures and measurements. The finish line design for the master die in this study was designed to be a rounded shoulder. A customized tray was fabricated using picca tray material over the spacer. Custom trays are considered to be more accurate than stock trays. Autopolymerizing acrylic resin has been one of the materials of choice for the fabrication of custom trays. **Pagniano et al.[16]** stated that autopolymerizing acrylic resin trays should not be used for at least nine hours after fabrication. Regular body (Aquasil) impressions were made after 24 hrs which was in accordance with **Eames W and Sieweke J.[17]**

Thongthammachat S et al stated that polyvinyl siloxane impression material has been shown to be the most dimensionally stable for up to 720 hours (30 days), without clinically significant dimensional changes**.** The casts were poured in Type IV die stone (Kalabhai Kalrock) with W/P ratio of 100:18.6. Each die was scanned and the die spacer thickness was set to **25µm** which was uniform throughout and terminated **1.4 mm** from the finish line. For measuring the marginal fit each coping was filled with the fit checker II (GC) and was seated on the master die with a standard finger pressure of **50N** until it was polymerized. Finger pressure was standardized by repeated trials and controlled using an electronic scale.

Statistical analysis was done using IBM SPSS Statistics 20. Descriptive statistics, paired t-test was performed. A paired t test was performed to compare the mean marginal adaptation of zirconia crowns before ceramic firing and after ceramic firing. P value < 0.05 was considered statistically significant. The p-value is less than 0.05, we reject the null hypothesis that there's no statistically significant difference between the means of two groups. The highest marginal discrepancy before ceramic firing was **13.63µm** and the lowest recorded was **3.55µm** because of differences in viscosity of the fit checker and placement forces**.** The highest marginal discrepancy after ceramic firing was **12.92µm** and the lowest recorded was **4.75µm.** The mean marginal discrepancy obtained was **8.07 µm** with a Standard deviation of **2.402.** There were no significant differences for any region in any marginal design before and after firing and glazing of the porcelain.

The results of our study highlight the fact that the marginal fit of the copings before ceramic firing was lesser than marginal fit after ceramic firing, but the difference between the two margins after firing was not significant. These findings suggest that ceramic firing cycles change the marginal fit of the copings. As there was no significant difference between the zirconia copings before and after ceramic firing, clinically it does not change things much. Limitations of this study include that the restorations were not cemented onto the tooth specimen to simulate the clinical scenario. If the specimens were cemented onto the tooth, it would be difficult to visualize the reference points if the margins were covered with luting material. The various cementation procedures might affect the marginal adaptation due to differences in cement viscosity and placement forces used during cementation.

V. CONCLUSION

The highest marginal discrepancy before ceramic firing recorded was **13.63µm** lowest recorded was **3.55µm**. The highest marginal discrepancy after ceramic firing recorded was **7.95µm** and after ceramic firing is **8.07µm.** This study only investigated the marginal gap however other parameters such as horizontal gap and internal fit could be evaluated. In addition, the study focused on the fabrication of a single crown. As such, the fabrication of splinted or multiple unit prostheses could determine if there is a difference in the performance of the scanning technology or the design and fabrication steps. Both tested procedures showed clinically acceptable marginal fit. There is no conclusive evidence of optimum fit of contemporary ceramic systems. This topic is heavily investigated and fit values reported are widely diverse and ranges from 7.5 µm to 206.3 µm. These variations can mainly be attributed to lack of coherence about the definition of "fit", along with the differences in methods employed to determine the fit, testing parameters followed and investigated.

Acknowledgment

I offer my fervent thanks to the Almighty for the blessings showered on me and guiding me through every step.
I am indebted to individuals too numerous to mention separately. I take this opportunity to thank everyone who has contributed in completing this manuscript.

I express my deep sense of gratitude to my respected teacher and guide, **Dr. K. Mahendranadh Reddy,** Professor and HOD for his tolerant nature and suggestions. His untiring enthusiasm and constructive criticism have made this study possible. He taught me how to question thoughts and express ideas. His patience and support helped me overcome many crisis situations and finish this dissertation.

I am thankful to **Dr. Y. Mahadev Shastry,** Professor, for his thoughtfulness and encouragement. I am grateful to him for holding me to a high research standard and enforcing strict validations for each research result and thus teaching me how to do research. I am also thankful to him for encouraging the use of correct grammar and consistent notation in my writings and for carefully reading and commenting on countless revisions of this manuscript.

I would like to thank my parents, **Dr. Md. Ameenuddin & Farhath Nawsheen** for their lifelong support, wisdom and direction. The sacrifices that they have made allowed me to pursue the aspirations and desires for my life and my career.

REFERENCES

1. Sadowsky SJ. An overview of treatment considerations for esthetic restorations: a review of the literature. *J Prosthet Dent 2006;96:433–442.*

2. Bachhav VC, Aras MA. Zirconia-based fixed partial dentures: a clinical review. *Quintessence Int 2011;42:173–182.*

3. Jacobs MS, Windeler AS. An investigation of dental luting cement solubility as a function of the marginal gap. *J Prosthet Dent 1991;65:436–442.*

4. Björn AL, Björn H, Grkovic B. Marginal fit of restorations and its relation to periodontal bone level. II. Crowns. *Odontol Revy 1970;21:337–346.*

5. Schwartz NL, Whitsett LD, Berry TG, Stewart JL. Unserviceable crowns and fixed partial dentures: life-span and causes for loss of serviceability. *J Am Dent Assoc 1970;81:1395–1401.*

6. Bergenholtz G, Cox CF, Loesche WJ, Syed SA. Bacterial leakage around dental restorations: its effect on the dental pulp. *J Oral Pathol 1982;11:439–450.*

7. Heintze SD. Systematic reviews: I. The correlation between laboratory tests on marginal quality and bond strength. II. The correlation between marginal quality and clinical outcome. *J Adhes Dent 2007;9:77–106.*

8. McLean JW, von Fraunhofer JA. The estimation of cement film thickness by an in vivo technique. *Br Dent J 1971;131:107–111.*

9. Reiss B: Long-term clinical performance of CEREC restorations and the variables affecting treatment success. *Compend Contin Educ Dent 2001;22:14-18.*

10. Reich S, Wichmann m, Nkenke E, proeschel P. Clinical fit of all ceramic three-unit fixed partial dentures, generated with three different CAD/Cam systems. *Eur J Oral Sci. 2005;113(2):174-9.*

11. P. Schaerer, T. Sato, A. Wohlwend. A comparison of the marginal fit of three cast ceramic crown systems. *Journal of Prosth Den, 59 ,1988, 534-542*

12. Sulaiman F, Chai J, Wozniak WT. A comparison of the marginal fit of In-ceram, IPS Empress and Procera crowns. *Int Journal of Prosth 1997 Sep 1:10(5).*

13. Gardner FM. Margins of complete crowns—Literature review. *The Journal of prosthetic dentistry 1982;48:396-400*. Both in vitro

14. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. *The Journal of prosthetic dentistry* 1989;62:405-408. Holmes def

15. The Effect of Porcelain Firing and Type of Finish Line on the Marginal Fit of Zirconia Copings. Mahroo Vojdani, Anahita Safari, Mina Mohaghegh, Soheil Pardis, and Farideh Mahdavi. *J Dent (Shiraz). 2015 Jun; 16(2): 113–120*.

16. Pagniano RP, Scheid RC, Clowson RL, et al: Linear dimensional change of acrylic resins used in fabrication of custom trays. *J Prosthet Dent 1982;47:279-283*

17. Eames WB, Sieweke JC, Wallace SW, et al: Elastomeric impression materials: Effect of bulk on accuracy. *J Prosthet Dent 1979;41:304-307*