Marginal fit of metal ceramic restorations with various finish lines

- An Invitro Study

A Dissertation submitted

in partial fulfillment of the requirements for the degree of

MASTER OF DENTAL SURGERY

BRANCH - VI
PROSTHODONTICS

to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

FEBRUARY 2005

CERTIFICATE

This is to certify that **DR. V. DEVAKI**, Post Graduate Student (2002-2005) in the Department of Prosthodontics, Tamil Nadu Govt. Dental College & Hospital, Chennai-03 has done this dissertation titled "***MARGINAL FIT OF METAL CERAMIC RESTORATIONS WITH VARIOUS FINISH LINES - An Invitro study***" under our guidance and supervision in partial fulfillment of the regulations laid down by the Tamilnadu Dr. M.G.R. Medical University, Chennai, for M.D.S., (Branch – VI Prosthodontics) part II degree examination.

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INTRODUCTION

Marginal seal is a critical factor for success of any dental restorations. Marginal seal is essentially dependant on the adaptation of the castings, luting cement used and the surface structure of the margins. If any cases where the fit of the cemented restoration is inadequate due to poor marginal seal, a thin line of the cementing medium is exposed due to the action of saliva, foreign bodies and oral fluids. This inaccuracy in the marginal fit stands as a reason for promotion of marginal leakage, encourages plaque, bacterial deposition initiates secondary caries and periodontal disease with a concomitant deterioration of the restoration.

A healthy co-existence between the dental restoration and their surrounding periodontal structures is the goal of the conscientious dental surgeon and the expectations of the patients.

In 20^{th} century itself innovative techniques and materials were introduced in this field for fabrication of restorations that is accurately fit over the prepared surface of the tooth. To fabricate these restorations various materials like metals, alloys, resins and ceramics were used. Regarding the different materials, metals and alloys have advantage of superior strength, but of its color esthetically not acceptable.

Due to lack of esthetic value metals are replaced by ceramics. Introduction of the ceramic in the dental field is a new advancement. Considering the other materials ceramic is esthetically good and also kind to the gingiva, but the inherent weakness with high sintering shrinkage has been its drawback of its universal acceptance.

The introduction of metal ceramic crown is the most popular complete veneer restoration in dentistry because it derives its esthetics from porcelain

and strength from underlying metal substructure and also marginal integration favourable for good marginal seal.

The fabrication of metal ceramic restoration is one of the recent advances in prosthetic dentistry eventhough various techniques and various types of porcelain materials available, marginal adaptation of the metal ceramic restoration is critical factor for most of the success of restoration.

Marginal adaptation depends mostly:

1. Geometry of tooth preparation
2. Finish line
3. Fabrication procedures
4. Underlying cementing medium etc.

REVIEW OF LITERATURE

It has been said that there is nothing as constant as change. The advent of metal ceramic started in the early 1950's when the porcelain was developed with co-efficient of thermal expansion similar to the existing dental casting alloys when it was introduced in the market. It was called at different times and different parts porcelain fused to gold, and porcelain used to metal (PFM), the term metal ceramic restoration (MCR) commonly used in the dental literature during the 1970's and 1980's.Metal ceramic exactly means a metal casting or coping which fits over the tooth preparation and ceramic that is fused to the coping.

Charles S Becker[10] **(1956)** – Discussed the construction of porcelain baked to gold alloys he mentioned that close marginal adaptation of metal ceramic crown to the gingival finish lines of a prepared tooth protects the pulp from a bacterial invasions, thermal conduction and thermal irritation. Finally

concluded that the bulk of the literature and research on complete crown margins were to classified on the categories such as (a) Location of the margin, (b) Configuration of the margin, (c) Fit of the margin

According to location of margins Charles Becker and the others conducted the margin placement and its sequences in the following manner.

Locato, Silness and New Conib[44] (1969 – 1974) - Conducted a study and showed that the subgingival margins exhibited an in increased accumulation of plaque while supra gingival margins did not. Finally he concluded that supra gingival margin location is devoid of any periodontal problems.

Carranza[14] (1973 – 1975) – Conducted a study, in that study says that location of the finish line margin depends on the dentist and the patient. This study concluded that location of finish line margin is where the dentist can best control in adaptation and the patient can effectively clean it. In reference to the configuration of the finish line the following studies were conducted.

E. Ebrashi et al (1969), **Faeah and Craig**[27] (1974) - Conducted the study that configuration of the finished margin was good for stress distribution when compared to a sharp angled shoulder. The conclusion of this study was done by means of photo elastic analysis.

Christengen's et al[16] (1966) - Conducted a study by comparing subgingial and supra gingival marginal openings. Concluded that acceptable subgingival marginal opening was 3.4 µm and acceptable large supra gingival marginal opening was 2.51 µm. They used the measuring microscope to measure the marginal discrepancy.

Cooper et al[19] (1971), **Jones et al**[41] (1971), **Eames et al**[26] (1978) - Conducted the study about the marginal opening of metal crown with respective dies. They found that vented castings sealed better than unvented

castings. Alternatively electro milling the inside of the casting, aquaregia etching and spacing the die prior waxing the crown reduced the marginal opening from approximately 110 µm – 45 µm.

John J Boyle, et al[39] (1993) – Conducted a study compared porcelain facial margins made with direct lift technique using high fusing shoulder porcelain and platinum foil technique with conventional body porcelain. Marginal accuracy was measured directly and the marginal sharpness computed by software program. Concluded that vita high fusing shoulder porcelain and vita SM 90 porcelain produced restorations that had significantly smaller mean facial marginal openings than crows created with platinum foil. The lack of marginal sharpness of porcelain facial margins may be influenced more by the die material further than by the marginal porcelain or technique.

Waerhang J M (1960), **Loe**[70] (1968) - Conducted a study after cementation of metal ceramic restoration in a periodontally healthy teeth and samples were examined after 6 months, 1 year, 2 years and concluded that plaque accumulation in the marginal openings were responsible for the inflammation of the gingival and periodontal breakdown.

Modelli C D et al[50] (1978) – Analysed that marginal discrepancy of porcelain fused metal restorations were reduced by application of copal varnish and cavity liners to seal the gap and reduce the marginal distortion

McClean J [47] (1980) - Conducted a study that shows comparative analysis of marginal discrepancy and cement film thickness, says that increased film thickness of luting cement leading to microleakage both in terms of crown seating and Fick's law of diffusion which states that the rate at which one substance differ through another is directly proportional to the concentration gradients of the diffusing substances.

Bergenho et al and Kawamusa et al [8] (1982) – Conducted a study and showed that marginal discrepancy of the restoration was the important etiological factor for the dental caries and pulpal disease. They concluded that marginal discrepancy leads to marginal leakage and promotes secondary caries that will leads to damage to the pulps finally result in pulpits and extraction of involved teeth.

Foster L V [30] (1990) - Examined the major causes of failure of the restoration was mainly due to the marginal leakage. A wide range of value of measurement of fit, exists in the literature from as little as 4 µm – 120 µm.

Christensen G J [16] (1956) - Studied the marginal fit of gold inlays and determined that the least clinically acceptable marginal opening was 39 µm. This value has been cited repeated as clinically acceptable marginal discrepancy. Concluded that the probable cause attributed to the marginal distortion of metal ceramic restorations involves both biological and mechanical factors such as margin design, alloy type and mismatch of porcelain metal thermal contraction.

Shelby[59] (1962) - Conducted invitro study that says porcelain was applied over the coping by opaque layer application, body porcelain application, shoulder porcelain application and firing procedure and concluded that each stages were responsible for marginal distortion and marginal discrepancy.

Tucillo J J [68] et al (1972) - Conducted in vitro study and stated that during the filing procedure the porcelain undergone shrinkage, the firing shrinkage was 12 – 15% and this firing shrinkage was responsible for distortion of the marginal fit. The shrinkage of the porcelain was associated with high temperature filing cycle of metal. In this study they conducted on shear

stress measurements. Concluded that porcelain induced stresses lead to distortion of metal.

Ando et al [2] (1972) - Concluded invitro study to compare the deformation of the porcelain, whether deformation was caused by porcelain bonding or a result of the heat treatment for degassing. Concluded that porcelain deformation was not caused by porcelain bonding but that is mainly the result of the heat treatment for degassing result in marginal distortion.

Iwashita et al [38] (1977) – Conducted invitro study they concluded that the large gap changes caused by not only as a result of the porcelain firing cycles but also mismatch of the porcelain metal thermal contraction and finally they concluded that metal have slightly higher coefficient of thermal expansion than that of porcelain itself for the better marginal adaptation.

Omar R [54] (1987) - Conducted in invitro screening electron microscope study. Concluded that the mean marginal openings for unveneered ceramometal restoration were lesser (11+4 μm), than those for veneered restoration (23+7μm). Few researcher showed conclusively that porcelain application does not influence the marginal distortion of castings.

McLean J W [47] (1974) - Conducted a study to know the marginal distortion of metal ceramic restoration, concluded that the mean value for marginal adaptation of copings were similar after its porcelain application. This study proved that porcelain application has no effect on marginal distortion of metal ceramic restorations.

Bulhana W T, [12] et al (1981) - Conducted a study in which marginal opening of the restorations not only the marginal areas, but other areas measured and concluded that porcelain proximity to the margin had no significant effect on the marginal opening.

Dehoff and Anusavice[22] (1984) - Conducted in vitro study to know whether the marginal distortion of porcelain metal restoration was related to porcelain metal contraction mismatches and design of copings. They concluded that marginal distortions caused by the porcelain metal contraction mismatches and not caused by design of the coping. So finally they concluded that coping design did not affect the fit of the restoration.

Campbell and Pelletier[13] (1992) – Concluded that all of the significant distortion occurred during the first thermocycling of the alloy and finally concluded that no distortion resulted from the application of porcelain in metal ceramic restorations.

Pascoe DF [56] (1978), - Conducted a invitro study to compare the marginal leakage of metal ceramic restoration which have a beveled and unbeveled finish line and concluded that 90°C shoulder margin have greater exposure of cement than 45°C beveled shoulder and chamfer margin have greater cement exposure than deep chamfer margin.

McLean SW [47] (1980) - Conducted a study and has described in interesting innovation of veyonsis concept. Instead of using opaque porcelain to form the initial margin a combination of 1/3 aluminous core porcelain to 23 conventional opaque porcelain by weight was used to form the margin and fired at high temperature. This resulted in a margin with less pyroplastic flow and a reduced tendency to round off during glazing and reduced the marginal leakage.

Staeting [65] **et al** (1981) - Evaluated the marginal integrity of metal ceramic restorations with and without collar preparation and finally he concluded that collarless facially buttered porcelain metal crowns were clinically unacceptable because the mean marginal openings were larger than that of

collar facial margins. Collar margins had a smaller marginal openings and clinically acceptable.

Hajime Hamaguchi [34] (1982) - Conducted invitro study to find the influence of firing temperature on the marginal adaptation of metal ceramic restorations regardless of marginal design. He concluded that regardless of marginal design, porcelain application and firing does not mechanically distort the facial margin.

Anusavice and **Carroll**[4] (1987) – Conducted invitro study whether thermal contraction differences between porcelain and the metal substructure influence marginal adaptation and concluded that thermal contraction differences were not the primary cause of distortion of the metal ceramic restorations.

Deniz Gamalmez and **Al Kumru** [23] (1995) - Conducted invitro study and concluded that the marginal fit changes during porcelain firing cycles with shoulder and chamfer finish lines. It revealed a greater change during the degassing stage, decrease in gap after opaque firing and a small increase in gap size after firing body porcelain. No significant differences were found when the effects of margin design and porcelain proximity to the fit of metal ceramic crowns were compared.

Antinio Bello and **Gavis** [3] (1977) – Suggested that the modified metal ceramic crown can be selected as a retainer for most short span fixed partial dentures. It has been assumed that the porcelain margin is inferior to the commonly used metal ceramic margin while few studies have demonstrated that porcelain margins have marginal openings that are as clinically acceptable as the metal ceramic margins.

Nakamura Y and **Anu Savice K J** [52] (1978) – Conducted a study to know the marginal discrepancy of metal ceramic crowns and their geometry of

tooth preparation and concluded that the marginal distortion of metal ceramic crowns decreases as the axial length become more uniform and increase the marginal openings when non-uniform and length of the preparation increases.

Stanley G, [66] **et al** (1994) - Examined porcelain labial margins after ultrasonic scaling and air polishing. This specimens were treated as three groups with (1) an air polisher; (2) an ultrasonic scaler, and (3) the ultrasonic scaler and the air polisher. Surface roughness was determined and selected specimens were observed under scanning electron microscope. Concluded that the specimens treated with the air polisher or the ultrasonic scaler and air polisher combination were less distorted than those treated with the ultrasonic scaler alone. The data suggested that careless use of an ultrasonic scaler or air polisher could substantially alter porcelain facial margins and increase the marginal distortion.

Ronald A, [58] **et al** (1979) – Concluded that degassing is an essential step in eliminating impurities from metal frameworks of porcelain fused-to-gold fixed partial dentures. This is accomplished by heating the framework in a porcelain furnace to approximately 1,900°F (1,038°C) and holding this temperature, absorbed gases are released from the metal and surface contaminants are burned off. This prevents contamination and bubble formation in the porcelain during firing. Unfortunately, the extreme temperatures used in degassing can have another undesirable effect. At such temperatures the framework loses some of its elastic strength and become susceptible to plastic flow. Tuccillo and Nielsen have shown that these property changes can result in a distortion or sag of the framework. If the retainers of the porcelain-to-gold fixed partial dentures are soldered together

rather than case in one piece, distortion may be even greater due to the lower melting range of the solder that leads to marginal distortion.

John J Boyle et al [38] (1993) – Conducted a study and compared porcelain facial margins made with the direct lift technique using high fusing shoulder porcelains and the platinum foil technique with conventional body porcelain. Marginal accuracy was measured directly and the marginal sharpness computed by the software program MacDraft. Both Vita high-fusing should porcelain and the Vita SM 90 porcelain produced restorations that had significantly smaller mean facial marginal openings than crowns created with platinum foil. Concluded that the lack of marginal sharpness of porcelain facial margins may be influenced more by the die material rater than by the marginal porcelain or the technique.

Yeo In-Sung, [71] **et al** (2003) – Conducted a study to compare the marginal adaptation of single anterior restorations made using different system of porcelain crowns. The in vitro marginal discrepancies of 3 different all-ceramic crown systems, Celay In-Ceram, conventional In-Ceram and IPS Empress 2 layering technique (control group of metal ceramic restorations). Concluded that the limitations of this study, the marginal discrepancies were all within the clinically acceptable standard set at 120 μm. However, the IPS Empress 2 system showed the smallest and most homogenous gap dimension, whereas the conventional In-Ceram system presented the largest and more variable gap dimension compared with the metal ceramic (control) restoration.

Herbert T. Shillingbug, [62] **et al** (2003) - Conducted a study with four finish lines were tested to determine what was effect of configuration of the finish line on the stability of labial margins of porcelain fused-to-metal restorations

during the stages of porcelain firing. These finish lines were chamfer, heavy chamfer with bevel, shoulder with bevel and the shoulder. Concluded that the relationship between preparation finish line configurations and marginal stability of porcelain fused-to-metal restorations during the firing cycle was studied. Four labial finish lines, with and without a bevel, were found to produce significantly less distortion in labial margins of porcelain-fused-to-metal restorations than do chamfer finish lines with and without a bevel.

Roberto et al [57] **(1993)** – Conducted invitro study and evaluates whether a standardized post soldering technique affect the marginal fit of restorations and measured the specimen at 3 specific points before and after the soldering, differences were found in the marginal openings of the both copings before soldering (49.9 μm) and after soldering (48.3 μm) and concluded that these were not clincically significant differences in the adaptation of the copings after the soldering procedure.

Osamu Ushiwata [55] **(2000)** – Conducted invitro study and evaluated the technique of internal adjustment of castings with the use of duplicated stone dies and a disclosing agent to improve marginal fit discrepancy and concluded that marginal fit discrepancy of copings were significantly reduced with an internal adjustment technique and tooth preparation with greater covergance and internally relieved castings recorded a better marginal fit.

Joavo (2000) – Conducted invitro study that standardization of a device that allowed fixation of specimens on a tool markers microscope with identical conditions according to the dimensional positioning of specimens, measuring locations and seating force. The device also allows mapping of the marginal discrepancies on the entire marginal perimeter of the tooth preparation.

Frederick [32] **et al** (1993) – Conducted a study to determine whether matching the physical properties of refractory die material to porcelain could increase the marginal accuracy of porcelain restorations and concluded that a match refractory porcelain system can produce restoration with significantly improved marginal accuracy.

SUMMARY

This present study evaluated the various finish lines such as shoulder, shoulder with bevel, deep chamfer, chamfer and their marginal adaptation, before and after the porcelain application. The product which was used in this study was inceram according to Jnsung Yeo et al (2003) revealed that mean gap dimensions and standard deviations at the marginal opening for Inceram 83 ± 55μm, celay 112 ± 40 μm, IPS impres 86 ± 44μm, inceram was selected. The specimens involved in this study were totally 20 stone dies which were nothing but individual tooth preparation with their corresponding finish lines. For our convenience specimens were grouped in 4 groups.

Group I Specimen with shoulder finish line 5 in number, Group II specimen with shoulder with bevel finish line 5 in number, Group III specimen with deep chamfer finish line 5 in number, Group IV specimens with chamfer finish line 5 in number. The specimens were waxed and casted and copings were fabricated. The fabrication of copings considered as a stage I. In this first stage marginal openings were recorded for the 4 groups of specimens with the help of traveling microscope in 4 different areas (mesial, distal, mid facial and any point in between the points). The values

were tabulated and statistical analysis was done with the help of one way Anova test.

In the second stage, porcelain was added for each specimen, fired in the porcelain furnace, the temperature and timings were scheduled as that of the text books. After applying the opaque layer, enamel dentin porcelain were applied. The specimens were fired, marginal openings were recorded for each group of specimens in predetermined areas (mesial, distal, mid facial and any point in between) the values were tabulated and statistical analysis done with the help of Anova test. After getting the mean openings and standard deviation of each group specimens were compared before and after porcelain application. According to one way anova test before porcelain application there is no clinically significant marginal distortion present in between four groups of specimen ($P > 0.05$ NS) and also says that after porcelain application group III, group IV specimens have marginal discrepancy in clinically significant amount present ($P < 0.001$ S).

CONCLUSION

It was conclude that the configuration of the finish line, has an effect on the marginal adaptation of the metal ceramic crowns. Correlating the statistical evaluation, and the mean marginal opening values before and after the porcelain application, the following conclusion confirmed

1. The Chamfer finish line configuration was best marginal adaptation than shoulder, shoulder with bevel finish line configuration before porcelain application.

2. Deep chamfer finish line configuration was good marginal adaptation than shoulder, and shoulder with bevel finish line before porcelain application
3. Shoulder finish line configuration was relatively good adaptation than shoulder with bevel finish line configuration.
4. Shoulder with bevel finish line configuration has least adaptation before porcelain application
5. But all the four type of finish line configuration has a clinically negligible marginal opening before porcelain application.
6. Shoulder with bevel finish line configuration was best adaptation than chamfer and deep chamfer finish line after porcelain application.
7. Shoulder finish line configuration has good adaptation than chamfer and deep chamfer finish line after porcelain application.
8. Chamfer and deep chamfer finish line configuration was least adaptation than any other finish line configuration and chamfer, deep chamfer finish line showed clinically significant marginal leakage.

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