EVALUATION OF EFFECTS OF PORCELAIN FIRING ON THE MARGINAL FIT CHANGES OF PORCELAIN-FUSED-TO -METAL CROWN FABRICATED UTILIZING TWO DIFFERENT MARGIN DESIGNS AND TWO COMMERCIALLY AVAILABLE BASE METAL ALLOYS

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ABSTRACT

Aim: To find the marginal fit of the porcelain fused to metal crowns by two different margin designs (shoulder and chamfer) and two commercially available base metal alloys.

Material and Methods: Tooth preparation of first central incisor for porcelain-fused-to-metal crown with shoulder margin and second incisor for porcelain-fused-to-metal crown with chamfer margin was done. Wax pattern of the same was prepared. Impression of both prepared ivorine incisors was made by light body impression material and poured with pattern resin. Both the patterns were invested and casted with cobalt chromium alloy for making master dies. Two wax patterns of unprepared central incisors were fabricated, one with shoulder margin and another with chamfer margin. These patterns were then cut back to the size of the coping. Four rings were invested. In each ring ten patterns, five with shoulder margin and five with deep chamfer margin were sprued together to ensure that each group would pass through the same investing and casting procedure, followed by ceramic firing and measurement.

Results: Marginal fit change or marginal discrepancy (before and after firing) between the groups was highly significant.

Conclusions: Veneered crowns exhibited highly significant marginal distortion than non- veneered copings after porcelain firing. Shoulder margin is better in minimizing marginal discrepancy compared to deep chamfer margin. Marginal discrepancy is less when cerabond base metal alloy is used with shoulder margin as compared to commend base metal alloy used for shoulder margin.

KEYWORDS: base metal alloy, porcelain fused to metal, marginal fit

INTRODUCTION

The full veneer crown is one of the most important restorations in the armamentarium of the restorative dentist. The restoration can restore severely deteriorated teeth. To fabricate these restorations various materials like metals, alloys, resins and ceramics are used. Among the different materials, metals and alloys have the advantage of superior strength, but their color is a major concern. Due to the lack of esthetic value, metals have been replaced by ceramics.

In spite of the variables that exist in the fabrication and function of the restorations, the porcelain-fused-to-metal (PFM) restorations still form the backbone of modern restorative dentistry[1].

The wide use of porcelain-fused-to-metal restorations has provoked questions among dentists regarding the fit. Marginal fit of a metal ceramic crown has been a critical prerequisite for a successful artificial crown. It has been widely observed that the fit of the porcelain fused to metal (PFM) restoration distorts during the high temperature firing cycles used for porcelain veneer application[2].

Studies on marginal fit changes have identified many factors, such as the mismatch of the porcelain-metal thermal contraction, alloy type, and preparation design, as contributing factors to the distortion. Most of these studies have compared precious metal alloys (gold) with base metal alloys. Considerable controversy continues to exist in the literature with regard to the effect of these factors[1].

So here, through this study an attempt is made to compare marginal discrepancy of two commonly used commercial base metal alloys.

MATERIAL AND METHODS

Two unprepared Ivorine central incisors (novo) were taken. (Figure 1). Putty indices of each unprepared central incisor were made. The Indices were then cut in the center, labio-palatally with the help of Stanley knife (Figure 2).

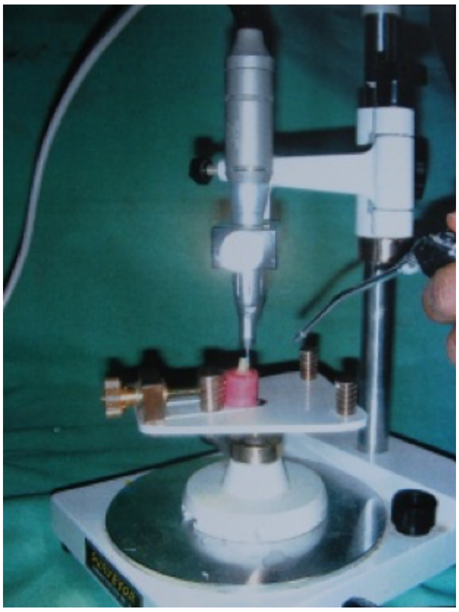
Tooth preparation of first central incisor for porcelain-fused-to-metal crown with shoulder margin and second incisor for porcelain-fused-to-metal crown with chamfer margin was done with the help of straight micromotor hand piece mounted on a surveyor (Figure 3).

Figure 1. Ivorine cental incisor.

Figure 2. Putty indices of un-prepared central incisor.

The prepared teeth were having following dimensions, the labial reduction was 1.2 mm, lingual and proximal reduction was 1 mm. The height was kept 8 mm (from the deepest part of the margin on labial side) and convergence angle was kept at 6°, the width of the margin was 1 mm[3].

Figure 3. Ivorine tooth on surveyor for tooth preparation.



A wax pattern of normal unprepared tooth was made over this prepared ivorine central incisor with the help of respective putty index made earlier. All of the above mentioned dimensions were verified with the wax gauge.

Two vertical extensions were made on palatal side of both the incisors extending from the margin downwards (Figure 4). This was done to guide the copings and assure its proper fit while measurement of marginal fit change.

Impression of both prepared ivorine incisors was made by light body impression material and poured with pattern resin. Both the patterns were invested and casted with cobalt chromium alloy for making master dies (Figure 5).

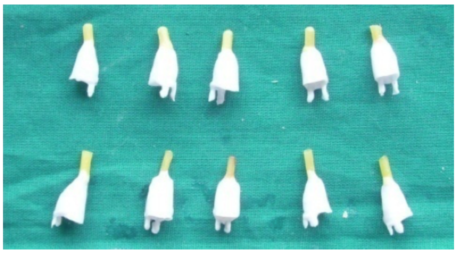
Two wax patterns of unprepared central incisors were fabricated, one with shoulder margin and another with chamfer margin. These patterns were then cut back to the size of the coping. Thickness of both the wax patterns were kept at 0.3 mm[4]. Two putty indices for both the type of wax pattern were made to create all the further wax patterns of uniform thickness of 0.3 mm (Figure 6).A total of 20 wax patterns with shoulder margin and 20 wax patterns with chamfer margin were obtained (Figure 7).

Figure 4. Prepared central incisors for shoulder and chamfer margin with palatal extension.

Figure 5. Master dies with shoulder and chamfer margin.

Figure 6. Putty index for metal coping.

FIgure 7. Wax patterns for copings.



Four rings were invested. In each ring ten patterns, five with shoulder margin and five with deep chamfer margin were sprued together to ensure that each group would pass through the same investing and casting procedure. The casting of first and second ring was performed with induction casting machine by using cerabond metal. The casting of third and fourth ring was performed by using Commend metal again with induction casting machine.

After casting all the copings were recovered. Copings were then minimally trimmed and adjusted for fitting on metal master die (Figure 8).

Both the Metal master die were taken and both were marked at three points as A, B, C: (A) midpoint of mesio-labial side, (B) midpoint of labial side, (C) midpoint of disto-labial side (Figures 9 and 10).

The measurements were determined by measuring between the reference mark on each die and the most apical point on the margin of the coping in a direction parallel to the long axis of the die and expressed as marginal fit changes[3].

Figure 8. Metal copings.

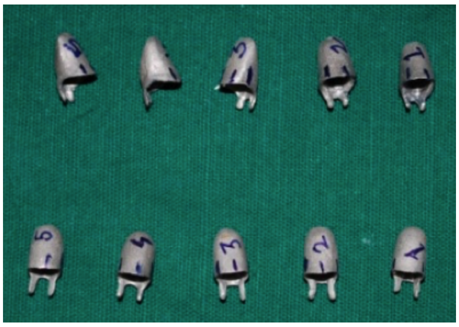


Fig 9. Marking the dies at three different points for measurement.

The copings were then replaced on the mounted metal die over the platform of the optical microscope; in such a way that light coming from optical microscope will fall on point A perpendicular. Same way B and C readings were recorded. A measuring microscope (optical microscope) equipped with mechanical micrometers calibrated to 1 µm at 100x magnification was used (Figure 11).

The marginal fit change was determined by measuring the space (marginal opening) between the margin of the coping and reference mark on the master die (Figure 12).

Figure 10. Marking the dies at three different points for measurement.

Figure 11. Optical microscope.

Same procedure was carried out for remaining copings and readings were recorded.

All copings underwent oxidation cycle subsequently followed by application of opaquer and dentin, and a layer of enamel porcelain. Contour of all the crowns was developed by using initial putty index of the unprepared ivorine central incisor. Finally all restorations were glazed. All this was done according to manufacturers recommendations (Figure 13).

Figure 12. Space (marginal opening) between the margin of the coping and reference mark on the master die.

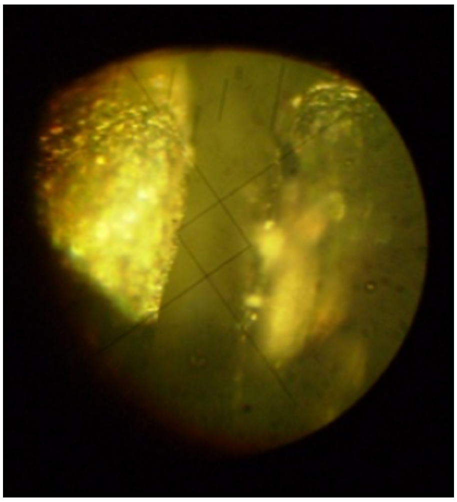


Figure 13. Porcelain firing.

Each restoration was again placed on respective metal master die and secured in the position with the help of clamp and readings at points A, B, and C were recorded similarly as done previously.

RESULTS

The samples were divided into four groups according to the types of margin design and alloy type; each group consisted of ten porcelain-fused-to-metal crowns as follow: Group I - Cerabond alloy copings with shoulder margin, Group II - Cerabond alloy copings with deep chamfer margin, Group III - Commend NB alloy copings with shoulder margin, Group IV - Commend NB alloy copings with deep chamfer margin.

DISCUSSION

Marginal fit is a critical factor in the success of any fixed dental restoration. Marginal opening can be described as 'the distance along the long axis of the die between the finish line of the preparation and the margin of the casting. The study carried here has evaluated the marginal discrepancy in porcelain-fused-to-metal crowns (PFM) under the influence of following conditions.

PRE-FIRING AND POST -FIRING

Some authors reported large gap changes, as a result of the porcelain firing cycles and mismatch of porcelain and metal thermal contraction.

Gemalmaz and Alkumru[5] evaluated thermal cycling distortion of 3-unit porcelain fused to metal frameworks at different firing stages and they found that the distortion seen after porcelain application firing was significantly greater than that seen after metal-conditioning firing.

Silver[6] and associate concluded

that shrinkage of the porcelain can produce metal contraction that may alter the adaptation of the restoration to the tooth.

Tuccillo and Nielson[7] found permanent deformation in porcelain-metal strips as a result of interfacial shear stress following firing.

Metal copings which fit during trial apparently do not fit after the porcelain has been added. The possibility of general metal warpage was identified as a problem early in the development of the restoration.

Buchanan et al.[8] has concluded that subsequent firing procedures showed a tendency to first increase marginal opening and then to decrease marginal opening as compared to the metal conditioning procedures.

In this study, the results obtained have statistically showed that there is highly significant difference in mean marginal discrepancy in all the groups studied after porcelain firing.

So in this study above results have showed that porcelain firing cycles have caused an increase in marginal discrepancy with mean marginal discrepancy pre-firing and post-firing ranging from 15 µm to 25 µm for various groups.

From above various observations the marginal discrepancy caused after the porcelain firing could be attributed to following reasons: (a) release of casting induced compressive stresses as a result of initial oxidation cycle[8,9], (b) formation of an oxide layer on the internal surface of the metal ceramic alloy during heating[8], (c) thermal incompatibility stresses[10], (d) contamination of the internal surfaces of the coping with porcelain, (e) reduction in the resilience of the metal because of rigidity of porcelain[10], (f) grain growth of the alloy, constricting the diameter of the crown[10], (g) improper support of the framework during firing[10], (h) inadequate framework design at the gingival level[10], (i) inadequate design of the framework as a whole[10].

USED OF DIFFERENT ALLOYS

Studies that related marginal distortion and alloy type have also been controversial. Some author concluded that there was greater marginal discrepancy in non-precious alloys. Dederich et al.[11] had conducted a study in which he used three different commercially available base metal alloys and he concluded that marginal opening was similar in all three base metal alloys.In this study both the metals used (cerabond and commend NB) are base metal alloys.

While comparing group I and group III, the highly significant statistical difference is observed.

This shows that marginal discrepancy is less when cerabond base metal alloy is used with shoulder margin as compared to commend base metal alloy used for shoulder margin.

Also when group II and group IV are compared no statistical difference is observed. This shows that there is no significant change in marginal discrepancy between cerabond and commend NB when they are used with chamfer margin. Results of this study disagreed with Dederich et al.[11].

From above various observations the marginal discrepancy caused after the porcelain firing could be attributed to the formation of thicker oxide layer.

USE OF DIFFERENT MARGIN DESIGNS

The margin is one of the components of the casting restoration most susceptible to failure both by biological and mechanical factors.

Shillinburg et al.[12] showed that marginal fit after various firing cycles was dependent on the design of the margin. They found that shoulder finish lines with or without a bevel produced less distortion in the labial margins compared with beveled and non beveled chamfer margins.

Fisher et al.[13] Using a sectioned impression to measure fit, and Dehoff and Anusavice[14] using finite element analysis, found that the design of the margin did not affect the ultimate fit of the restoration.

In this study, when group I (Cerabond alloy with shoulder margin) with group II (Cerabond alloy with deep chamfer margin) and group III (Commend NB alloy with shoulder margin) with group IV (Commend NB alloy with deep chamfer margin) are compared, it shows statistical significant difference in marginal discrepancy.

Results show that shoulder margin is better in minimizing marginal discrepancy compared to deep chamfer margin. From above various observations the marginal discrepancy caused by marginal design could be attributed to the rate of oxide formation[15].

CONCLUSIONS

In this study, an attempt was made to evaluate effects of porcelain firing on the marginal fit changes of porcelain- fused-to- metal crown constructed utilizing two different margin designs (shoulder and chamfer) and two commercially available base metal alloys (Cerabond and Commend NB).

With the help of statistical analysis and results obtained following conclusions are drawn: (1) veneered crowns exhibited highly significant marginal distortion than non- veneered copings after porcelain firing. So in this study porcelain firing cycles have caused an increase in marginal discrepancy with mean marginal discrepancy pre-firing and post-firing ranging from 15 μm to 25 μm for various groups; (2) results showed that shoulder margin is better in minimizing marginal discrepancy compared to deep chamfer margin. Statistically significant difference in marginal discrepancy was observed; (3) in this study both the metals used (cerabond and commend NB) were base metal alloys. Results have showed that marginal discrepancy is less when cerabond base metal alloy is used with shoulder margin as compared to commend base metal alloy used for shoulder margin. Results have showed that there is no significant change in marginal discrepancy between cerabond and commend NB when they are used with chamfer margin.

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