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EVALUATION OF THE MARGINAL ACCURACY IN PORCELAIN FUSED TO METAL COPINGS FABRICATED IN TWO DIFFERENT FINISH LINES USING THREE DIFFERENT DIE MATERIALS -A STEREOMICROSCOPIC ANALYSIS AS A COMPARATIVE STUDY

SUBHA JOSHI [a*], SHIV SAGAR TEWARI [a] AND DR.PRIYA LAXMAN VASWANI [a]

[a] Department of Prosthodontics, Crown and Bridge, School of Dental Sciences, Krishna Institute of Medical Sciences, Deemed to be University, Karad, India.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: In the 20th century itself innovative techniques and materials were introduced for the fabrication of restorations that 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 the advantage of superior strength, but for color, it is esthetically not acceptable. Due to a lack of esthetic value metals are replaced by ceramics.
Objective: To compare the effect of two different marginal geometries shoulder and deep chamfer on metal-ceramic copings fabricated with the use of three different die materials Conventional Type IV Gypsum, epoxy resin, resin-modified Gypsum (Synthetic Gypsum).
Methods: Two ivorine mandibular first molars were prepared using diamond points for receiving Full veneer porcelain fused to metal restorations. The two designs of circumferential finish evaluated in this study were shoulder and deep chamfer.
Results: Tests specimen fabricated on 3 groups of die material each having shoulder and deep chamfer finish line were analyzed under a stereomicroscope at four points, following results of vertical marginal gaps in µm were recorded.

**Corresponding author: Email: subhajoshikims@outlook.com;*

Conclusion: It is thus concluded from the above study that dies fabricated using three different materials in two different finish lines i.e shoulder and deep chamfer did not exhibit a statistically significant difference in terms of marginal accuracy and either of these finish lines can opt for fabrication of metal-ceramic restorations.

Keywords: Alloys; ceramics; innovative techniques; metals; porcelain; resins.

1. INTRODUCTION

The advent of metal ceramics started in the early 1950s when porcelain was developed with a coefficient 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 of porcelain fused to gold, and porcelain used to metal (PFM). The term metal-ceramic restoration (MCR) was commonly used in dental literature during the 1970s and 1980s [1]. Metal ceramic exactly means a metal casting or coping which fits over the tooth preparation and ceramic that is fused to the coping. In the 20th century itself, innovative techniques and materials were introduced in this field for the fabrication of restorations that accurately fit over the prepared surface of the tooth [2]. To fabricate these restorations various materials like metals, alloys, resins, and ceramics were used. Regarding the different materials, metals and alloys have the advantage of superior strength, but their color is esthetically not acceptable. Due to a lack of esthetic value metals are replaced by ceramics. Introduction of the ceramic in the dental field was an advancement [3]. Considering the other materials ceramic is esthetically good and also kind to the gingiva, but the inherent weakness with high sintering shrinkage has been the drawback of its universal acceptance. The introduction of the metal-ceramic crown is the most popular complete veneer restoration in dentistry because it derives its esthetics from porcelain and strength from the underlying metal substructure and also marginal integration favorable for good marginal seal [4]. Even though various techniques and types of porcelain materials are available, the marginal adaptation of the metal-ceramic restoration is a critical factor for most of the success of restoration [5].

Dies are subjected to considerable flexural strain when removed from impressions, duplicated to make refractory casts for dental ceramics, or when dental restorations are seated. While no single die material possesses all the ideal properties for an indirect working model, gypsum products have gained general acceptance because of their close approximation of the critical properties of an ideal die material [6]. Restoration of teeth using indirect castings made from lost wax technique has traditionally been used in prosthetic dentistry. Die is a positive replica of a prepared tooth that duplicates accurately the prepared tooth and surrounding soft tissues. Die can be fabricated from several materials [7]. Many die systems are available today which ensure accurate maintenance of the prepared teeth to the adjacent teeth. The choice of die material and system depends on the operator, as none fulfills all the requirements [8]. The advantages and disadvantages of each must be weighed and the choice depends on the requirement of the particular situation. A series of procedures are performed to attain a well- fitting casting, each of which individually influences the fit. The accuracy of indirect castings is associated with the dimensional stability of die materials, as a die must be able to reproduce the dimensions and detail of the tooth preparation while resisting damage during removal from the impression and cast fabrication procedures [9]. Die materials currently available include improved dental stone, resin-reinforced stone, epoxy resin, metals (silver and copper plated), and polyurethane resin. International Standards Organization type IV and V dental stones are among the most widely used die materials due to their excellent dimensional accuracy, low cost, and ease of use [10]. However, dental stones have less than desired strength, poor detail reproduction, and low abrasion resistance for complex prosthodontic procedures. Alternatives exist in the form of epoxy resin; polyurethane resin-reinforced stone and electroformed dies. Resin dies materials (epoxy and polyurethane) offer superior physical properties when compared to dental stones but are limited by dimensional changes and working difficulties during fabrication [10]. Charles S Becker [11] 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 bacterial invasions, thermal conduction, and thermal irritation. Finally concluded that the bulk of the literature and research on complete crown margins were to be classified into the categories such as a) Location of the margin, b) Configuration of the margin, c) Fit of the margin.

Mondelli C D et al. [12] analyzed that the marginal discrepancy of porcelain fused metal restorations was reduced by the application of copal varnish and cavity liners to seal the gap and reduce the marginal distortion. Bergenholtz et al. [13] conducted a study and showed that marginal discrepancy of the restoration was an important etiological factor for

dental caries and pulpal disease. They concluded that marginal discrepancy leads to marginal leakage and promotes secondary caries that will lead to damage to the pulps finally resulting in pulpits and extraction of involved teeth. Omar R [14] (1987) conducted an invitro screening electron microscope study and the author concluded that the mean marginal openings for unveneered ceramometal restoration were lesser (11+4 μm), than those for veneered restoration (23+7μm). Vishal Singh et al. [15] conducted a study to evaluate and compare the marginal accuracy of three porcelain fused with metal alloy using ringless and closed ring casting techniques. Studies investigating the accuracy of resin dies have discouraged their clinical use due to the significant dimensional shrinkage as compared to stone dies. In order to achieve a satisfactory restoration, the working cast or die must be dimensionally accurate and it should exhibit a certain degree of long-term accuracy [16].

This research therefore would aim at calibrating the vertical marginal gaps or inaccuracies due to the use of widely and commercially available die materials, for frequently given designs of porcelain fused to metal restoration using a stereomicroscope.

2. MATERIALS AND METHODS

MATERIALS USED: -

1. Two Ivorine mandibular First Molars
2. Chrome cobalt alloy (SP2-BEGO-Germany)
3. Mild steel for base
4. Diamond points (SS white TR 21)
5. Airotor Handpiece (NSK ,CONFIDENT, India Pvt Ltd)
6. Caulk Tray Adhesive (Dentsply Caulk)
7. Poly vinyl siloxane impression material-Type 2 Medium Bodied Consistency (Aquasil Monophase, Denstplytm)
8. SLA/ SLS resin
9. Type IV Gypsum-Die Stone (Kalrock-Kalabhai Karson Mumbai Pvt Ltd)
10. Synthetic Gypsum-Die stone (Synarock, XR, DFS, Germany)
11. Epoxy Resin –(Epoxy Compound-Pidilite Industries Limited)
12. Measuring Cylinder
13. Precision Balance, Model CY-200 (Citizen, Mumbai-India)
14. Nickel –Chromium Alloy (Me alloy-Dentsply)
15. Phosphate Bonded Investment material –Wirovest (BEGO-Germany)
16. Spruing wax (BEGO-Germany)
17. Debubbliser (Dentecon)
18. Inlay wax (DFS) and Cervical Wax
19. Dipping Wax (Elaflex- BREDENT- Germany)
20. Wax pot (BREDENT-Germany))
21. Feviquick (Pidilite Industries Limited)
22. Die Spacer (BREDENT-Germany)
23. Die lubricant (BREDENT-Germany)
24. Peter K Thomas Waxing Instruments (GDC Marketing-Punjab, India)
25. Iwanson Wax Gauge
26. Casting ring –Ringless (DFS-Germany)
27. Crucible former (DFS-Germany)
28. Centrifugal Induction casting machine (BEGO-Germany)
29. Vaccum Mixer with Vibrator (Maestra-Spain)
30. Preheating and Heating Furnace (7*7*9=1200 Digital Unident Instruments)
31. Tunsten Carbide Burs Long Fluted (DFS-Germany)
32. Carborandum Disk (DFS-Germany)
33. Mandrel (DFS-Germany)
34. Cool wheel (DFS-Germany)
35. Rubber wheel (DFS-Germany)
36. Lava design Software
37. Magics Software
38. Cambride Software
39. Projet 7000 SLA 3D printer series. (Germany)
40. Plastic laser Sintering Solutions –FORMIGA P 110 from EOS(Germany)
41. Stereomicroscope (Wuzhou New Found Instrument Co. Ltd China)
Model: XTL 3400e ,Magnification:10X
42. Image Analysis System

Make Chroma Systems Pvt Ltd ,India. Model :MVIG 2005

METHOD: -

1) Preparation of Standard Metal Model through CAD(Computer-Aided Design/CAM Computer-Aided Manufacturing- Two Ivorine mandibular first molars were prepared using diamond points for receiving full veneer porcelain fused to metal restorations. The two designs of circumferential finish evaluated in this study were shoulder and deep chamfer. A circumferential shoulder margin was prepared such that the width of the shoulder prepared was 1mm wide. For deep chamfer, the ivorine tooth was prepared circumferentially such that the width so obtained was 1mm.

These prepared ivorine teeth were scanned using a 3M Lava Optical Scanner and contra spray. Scanned images were exported to STL (StereoLithography)Format. The Design in STL Format was imported into a Plastic Laser Sintering system for milling, and chrome cobalt models of shoulder and chamfer margins were milled such that

the distance from the base to the finish line for each of the models was 10mm (Fig. 1).

These models so prepared were welded to a metal base, this base was fabricated in mild steel. The base had specific orientation grooves, these grooves served for the orientation of the custom tray to be fabricated for impression making, with corresponding projections that fit into the grooves. The base was rectangular in shape having dimensions of length= 6cm, width=3cm, and height =2cm. A total of four grooves were milled on each base (reference protocol). Two V (triangular) shaped grooves (Fig. 2), one larger in dimension with respect to the other milled on one wall of the base, and on the opposite wall half round grooves one larger in dimension with respect to the other were milled.

3. RESULTS

The mean of marginal gap values of every sample was calculated. The mean values of vertical gaps in dies fabricated in epoxy resin for both the finish lines were found to be beyond the normal limits(120 µm) exhibiting a range of 275-534 µm.

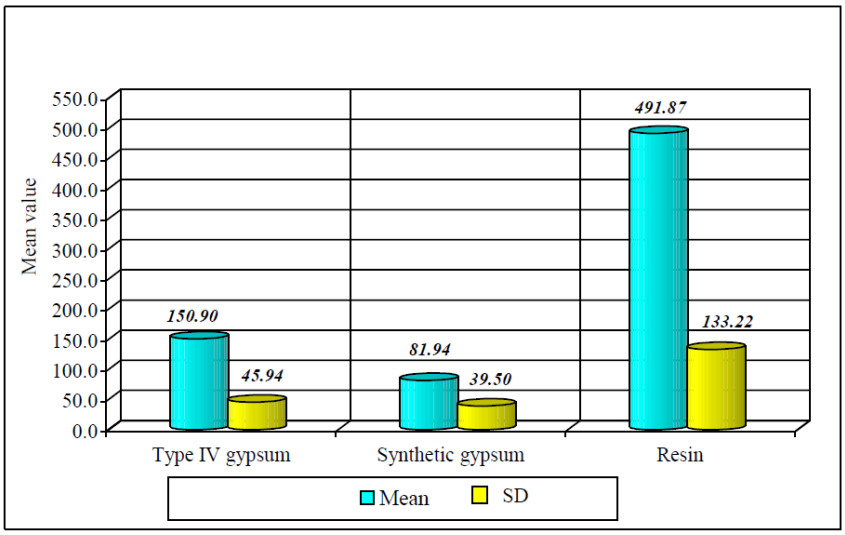

Fig. 1. Graphical representation of test samples fabricated on 3 groups of dies having chamfer finish line plotted against their mean values of vertical marginal gaps

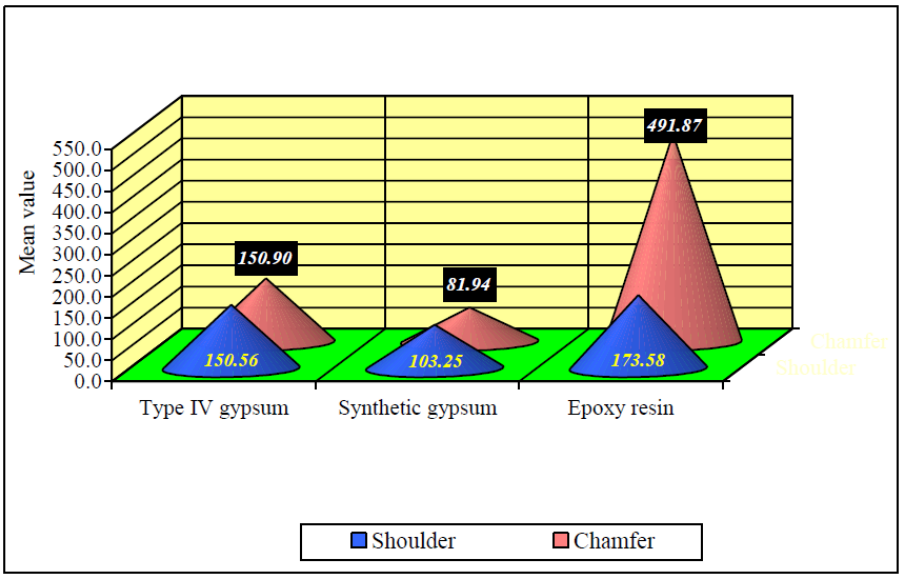

Fig. 2. Graphical representation of test samples fabricated on 3 groups of dies having shoulder and chamfer finish lines plotted against their mean values of vertical marginal

4. CONCLUSION

Our conclusions from the above study are the dies fabricated using three different materials in two different finish lines i.e shoulder and deep chamfer did not exhibit a statistically significant difference in terms of marginal accuracy and either of these finish lines can be opted for fabrication of Metal ceramic restorations. Epoxy resins although accurate in detail reproduction, undergo considerable polymerization shrinkage (0.16%) producing higher vertical marginal discrepancy when compared to stone dies. Stone dies used in this study i.e Type IV Gypsum and Resin modified Gypsum exhibit comparable results, but dies fabricated using resin-modified gypsum exhibited vertical marginal discrepancy within the clinically acceptable range, had better marginal adaptation and had accurate fit compared to dies fabricated using Type IV Gypsum.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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