

AN EVALUATION OF THE EFFECTS OF MARGINAL DESIGN, DIE SPACER, AND SEATING FORCE ON THE MARGINAL FIT OF CAST METAL CROWNS AFTER LUTING – AN INVITRO STUDY

¹ Vara Lakshmu U ¹ Assistant professor
² Sudha madhuri D ² professor-In-Charge
³ Gopinath A ³ Professor and Head

^{1,2} Department of Prosthodontics, Government Dental College and Hospital, Vijayawada, Andhra Pradesh, India.

³ Department of Prosthodontics, SIBAR Institute of Dental Sciences, Guntur, Andhrapradesh, India.

ABSTRACT: The marginal adaptation of cast metal crowns is essential for the success of cast restoration. The marginal design, die spacer and the seating force are considered as important factors effecting the marginal fit of cast metal crowns. Aims and Objectives; The aim and objectives of the present study is to evaluate the marginal fit of cast metal crowns 1. With three different marginal designs that are shoulder, shoulder with bevel and chamfer 2. With and without die spacer 3. Under seating forces 100N and 300N. **METHODOLOGY:** The study was done using 3 brass dies of 6mm height 10° taper with three different marginal designs shoulder, shoulder with 45° bevel and chamfer. 20 impressions of each metal die were made and casts were poured. 10 specimens of each group were coated with die spacer while the other 10 specimens were to serve as control group. Cementation done with GIC under two different seating forces (100N and 300N). The marginal discrepancy is determined by measuring the crown height before and after cementation. From this study it was concluded that specimen with combination of chamfer marginal design with die spacer under 300N seating force exhibited superior marginal adaptation.

KEY WORDS: Marginal design, die spacer, shoulder, shoulder with bevel, chamfer.

INTRODUCTION

The marginal adaptation of cast metal crown is very much important for success of the cast restoration. The factors which effect the marginal adaptation are the marginal design, size and shape of the prepared teeth, type of cementing medium, cement space, and magnitude of seating force.

The marginal discrepancy of the cast metal crowns may result in cement breakdown, plaque accumulation leading to caries formation and sensitivity, finally failure of restoration.

According to GPT- 8 marginal design is defined as "The outer edge of a crown, inlay, onlay or other preparation. The marginal design should provide sufficient bulk of the material and it should be easy to prepare without overextensions or unsupported enamel. The four basic types of finish lines are shoulder, shoulder with bevel, chamfer and knife edge. The selection of marginal design should be based on the type of crown, esthetic requirements, ease of preparation and operator experience.

The marginal design of the preparation affects the width of the band of the cement exposed in oral fluids after luting. **Gavelis et al.**¹ confirmed that feather edges, shoulders and chamfers with parallel bevels had the smallest marginal opening.

A space should exist between the internal surface of the casting and prepared tooth surface which provides room for the luting agent and allows complete seating of the restoration after cementation². There are many methods to create this space like grinding the inner surface of the casting, etching the internal surface of the casting with aqua regia, electro chemical milling of the inner surface, increased expansion of the investment mold and application of die spacer³. Among all methods die spacer application considered as an effective method.

Die spacer provides space for the cement film and relieves the hydraulic pressure during the initial stages of cementation and facilitates distribution of cement with minimal frictional resistance.

The seating force during initial set of cemented crown also influences the marginal fit of the crown. The maximum biting force generated by the masticatory muscles varies from 42N – 1245N. The magnitude of force is greater in the molar region and less in the anterior region⁴. This can be achieved by seating the crown in place with finger pressure and then ask the patient to bite in centric occlusion with maximum force.

The purpose of the study is to compare the affect of marginal design, the die spacer and magnitude of seating force on the marginal fit of cast metal crowns.

MATERIALS AND METHODS:

The present study was conducted to evaluate the effects of marginal design, die spacer and seating force on the marginal fit of cast metal crowns.

Materials used:

1. Poly vinylsiloxane impression material (AFFINIS – COLTENE WHALEDENT) batch no.6775, Switzerland – Putty and light body.
2. Auto polymerized acrylic resin DPI - INDIA
3. Type – IV Dental stone – Kalrock, Bombay, India
4. Die spacer – AMMAN GIRBACH, Germany, Batchno.782140.
5. Casting inlay wax(blue) – Dentorium products inc. 800-847- 4209, Newyork.
6. Investment material – WIROVEST – Bego, Germany.
7. Ni- Cr Alloy pellets – Wirloyloy , Bego, Germany.
8. Glass ionomer cement- Hybond, Shofu, Kyoto, Japan.

ARMAMENTARIUM USED:

Three Brass metal dies prepared on CNC lathe (M Tab – Denford) , with different margin designs shoulder, shoulder with 45° bevel and chamfer.

EQUIPMENT USED:

1. Vaccume mixer – Easy mix – Gerate – Nr.2991173
2. Wax burnout furnace- Technico, Chennai, India.
3. Sand blasting unit – Novo dual blaster, Novo Dental Products , Mumbai, India.
4. Casting machine – Bego, fornexT , Model no.26140.
5. Universal testing machine (UTB 9103 – ACHITECH, Dak system Inc.)
6. Digimatic indicator – Mitutoyo, Japan.

METHODOLOGY

Three metal dies were prepared on CNC lathe with three different finish lines shoulder, shoulder with 45° bevel and chamfer(Fig.1.) Each die had a convergence of axial wall of 10° and the height of the preparation was 6mm, the width at the base was 10mm.The margin designs were 1mm wide, 90° shoulder, shoulder with 45° bevel of 5mm and chamfer. The design of the die was identical to that described by Gavelis et al (1981)¹ and simulated to complete crown preparation on a molar and used in clinical research studies.

A total 60 impressions of the three metal dies were made, 20 impressions from each metal die with poly vinyl siloxane impression material by putty wash technique using custom trays fabricated on each metal die with autopolymerised acrylic resin and all impressions were poured with type IV die stone using manufacturer's instructions(Fig.2).

Two coats of die spacer (Amman Girbach, Germany) were painted according to manufacturer's instructions of each coating is about 15µm in thickness (total thickness of 30µm) on ten dies of each type (total 30 stone dies), and the other ten dies of each type (total 30 dies) were served as control group.

After applying a thin layer of die lubricant, the stone dies were submerged in melted wax (inlay casting wax) and the wax patterns are assumed to have a uniform thickness of 1mm after attaching the sprue formers, the patterns were invested with phosphate bonded investment material. The wax was eliminated by time and temperature (750- 900°C) controlled wax burnout, castings were carried out in induction casting machine. The castings were finished and polished until the castings appeared to fit their respective dies passively but were not easily dislodged.

Marginal seating discrepancy is the difference in gingivo – occlusal height of the crown before and after cementation. The crown height was measured before cementation using a digimatic indicator. The independent values were recorded in millimetres and the mean was calculated. (Fig.3 and Fig.4).

The Glass ionomer cement (Hybond – Shofu) was mixed according to the manufacturer's instructions, the powder liquid ratio of 1:2 is mixed on a cool dry mixed pad for 1 minute. A small amount of cement was painted on the margin and axial walls of the inner surfaces of each crown. The crown was initially seated on the master die in the correct position with minimal hand force to prevent crown tilting. Then the crowns were subjected to designated seating force either 100N/300N from Universal testing machine (UT13 9103- ACHITECH, DAK System,

Table.I. GROUPING OF SPECIMEN

| Name of the specimen | No. of Specimen |
|---|-----------------|
| Shoulder | 20 |
| Chamfer | 20 |
| Shoulder with 45bevel | 20 |
| Shoulder margin with die spacer | 10 |
| Shoulder margin without die spacer | 10 |
| Chamfer margin with die spacer | 10 |
| Chamfer margin without die spacer | 10 |
| Shoulder with bevel with die spacer | 10 |
| Shoulder with bevel without die spacer | 10 |
| Shoulder margin with die spacer under 100N seating force | 5 |
| Shoulder margin with die spacer under 300N Seating force. | 5 |
| Shoulder margin without die spacer under 100N seating force | 5 |
| Shoulder margin without die spacer under 300N seating force | 5 |
| Chamfer margin with die spacer under 100N seating force | 5 |
| Chamfer margin with die spacer under 300N Seating force | 5 |
| Chamfer margin without die spacer under 100N seating force | 5 |
| Chamfer margin without die spacer under 300N seating force | 5 |
| Shoulder with bevel with die spacer under 100N seating force | 5 |
| Shoulder with bevel with die spacer 300N seating force | 5 |
| Shoulder with bevel without die spacer under100N seating force | 5 |
| Shoulder with bevel without die spacer under 300N seating force | 5 |

INC.) within 2 minutes from the start of mixing and the cement sets after 7 minutes.

The castings and metal dies were removed from the universal testing machine after the cement had set and the post cementation measurements were recorded with digimatic indicator (Mitutoyo, Japan). The differences between pre and post cementation measurement were designated as seating discrepancies.

RESULTS: A paired t test and two factor analysis of variance were used to determine the significance of various factors on marginal discrepancy of complete metal crowns.

DISCUSSION:

Marginal integrity is considered to be an important factor for the success of a cast restoration. The margin of the casting should be closely adapted to the prepared tooth surface to prevent failure of the cast restoration.

The factors which influence marginal integrity are marginal design, size and shape of the prepared teeth, type of cementing medium, manipulation of the cement, cement space and magnitude of seating force. The present study is to compare the effect of marginal design, the die spacer and magnitude of seating force on the marginal fit of cast metal crowns.



Fig.1. Three metal dies with different margin designs - shoulder, chamfer, shoulder with 45° bevel

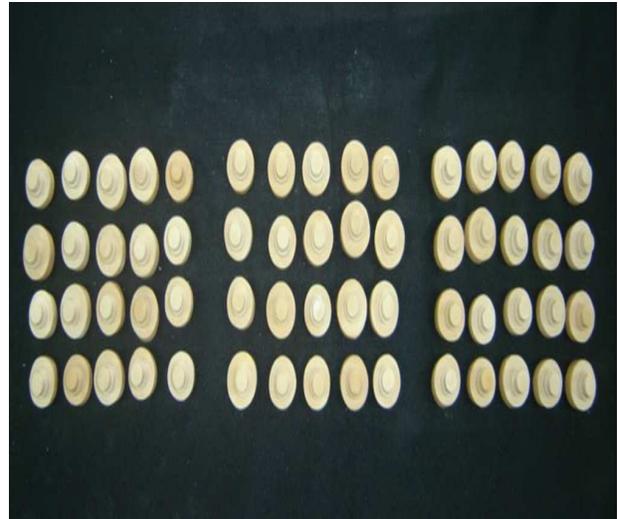


Fig.2. Stone die specimens

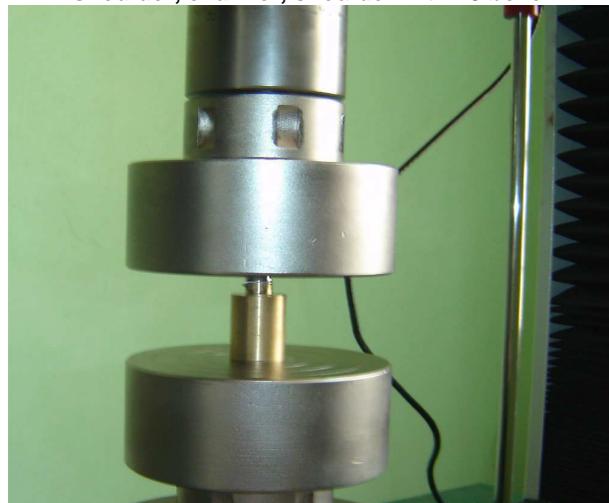


Fig.3. Application of seating force



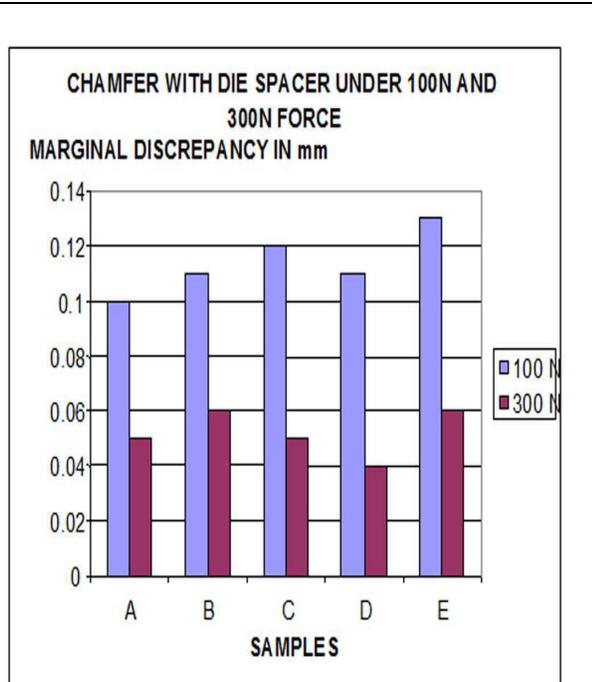
Fig.4. Measuring the marginal discrepancy with digimatic indicator

Marginal design:

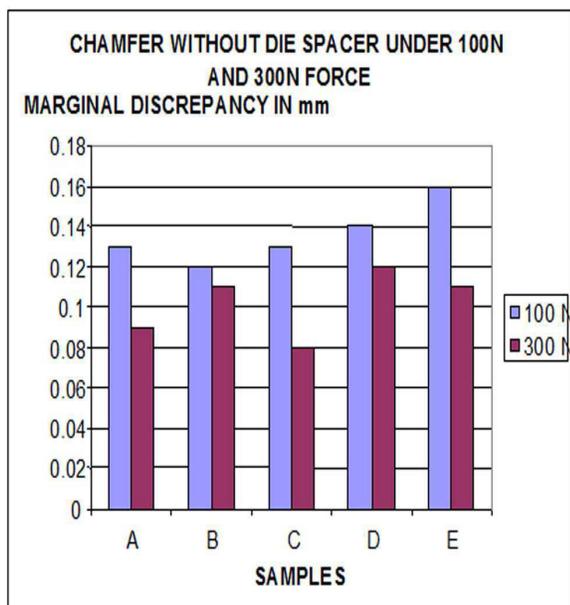
There are a number of studies conducted on the influence of marginal design of complete cast crowns by several authors like **C.J.Wang** (1992)⁵ has compared the marginal fit of crowns with marginal designs shoulder, and shoulder with 65° bevel and concluded that the beveled preparation showed superior marginal seating. **Gavelis et al** (1981)¹ had conducted a study on the effect of various finish line preparations on the marginal seal and occlusal seat of full crown preparation and concluded that the feather edge and parallel bevel preparations demonstrated the better marginal seal.

Die spacer:

Kaufman E.G. et al (1961)⁶ and **Rosensteil S.F** (1993)² in their studies concluded that internal relief can be best achieved by application of die spacer. Die spacer creates space for the cement film and relieves hydraulic pressure during the initial set of cement and facilitates distribution of cement with minimal friction resistance. The ideal dimension for the cement space has been suggested that 20-40µm for each wall. **C.J.Wang et al.** (1992)⁵ in their studies had concluded that the application of a die spacer significantly improved crown seating and used 4 coats of die spacer in alternate layers and believed that this method would ensure 24µm of thickness.



Graph.1. Chamfer with die spacer under 100N and 300N force



Graph.1. Chamfer without die spacer under 100N and 300N force

Magnitude of seating forces:

The masticatory forces in oral cavity ranges from 42-1245N it is higher in posterior region when compared to anterior region³. Literature shows the combination of heavy cementation force and lubricating effects of free

flowing cement improved the seating of crowns. **Chu.J.Wang et al (1992)⁵** in their studies revealed that elevation of seating force from 5-30lb significantly improved crown seating. **George W.Kay.et al (1986)⁷** demonstrated that the greater the pressure applied resulted in better seating of crowns.

The procedure of this study was done by using 60 Ni – Cr cast crowns with 20 specimens for each of the three different finish lines that are shoulder, shoulder with 45° bevel and chamfer were prepared. Of these 20 specimens of each group 10 specimens were prepared with application of die spacer and 10 specimens without die spacer. Of these 10 specimens 5 were seated with force of 100N and the other 5 specimens were seated under 300N. The cast crowns were cemented with Glass ionomer cement on metal dies and the marginal discrepancy of 12 groups specimens with parameters being three types of finish lines shoulder, shoulder with 45° bevel and chamfer two variants of seating forces (100N – 300N) with and without die spacer are tabulated.

From the foregoing discussion it is apparent that the specimen with chamfer finish line with die spacer under a high seating force 300N has resulted in decreased marginal discrepancy. This finding is in agreement with the studies of **Anthony H.L Tjan (1992)⁸**, **Chu.J.Wang (1992)⁵**, **Morakot Tutuprawon (1999)⁹**, **J.R.Gavelis (1982)¹** and **FabioM..Milan et al(2004)¹⁰** and others.

The other conclusions drawn from this study were the chamfer marginal design exhibited the least marginal discrepancy followed by shoulder with 45° bevel and shoulder respectively. Specimens with die spacer showed lesser marginal discrepancy than the specimen without die spacer. Specimens seated with 300N force showed lesser marginal discrepancy than the specimens seated under 100N force.

LIMITATIONS OF THE STUDY:

Since the metal crowns are cemented on metal dies , the mode of adherence of cement is different from a clinical condition and only static forces were used for the cementation in this study , hence further studies required to evaluate the effect of application of a combination of static and dynamic forces and cementation of the cast metal crowns on the prepared natural teeth.

CONCLUSION

Within the limitations of this present study the following conclusions were drawn

- The chamfer marginal design exhibited the least marginal discrepancy followed by shoulder with bevel and shoulder finish lines respectively

- Specimen with die spacer showed lesser marginal discrepancy than the specimen without die spacer.
- Specimen seated with 300N force showed lesser marginal discrepancy than the specimen under 100N force.
- Specimens with combination of chamfer margin with die spacer under 300N force exhibited lesser margin discrepancy than the other groups of specimens.

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Corresponding Author

Dr. U. VARALAKSHMI, M.D.S,
 Assistant Professor,
 Department Of Prosthodontics,
 Govt. Dental College & Hospital,
 Vijayawada, Andhrapradesh.
 E mail:
varalakshmi_prosdent@yahoo.co.in,
 Phone No; 9848926869