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# The Effect of Screw Access Channel Design on Porcelain Fracture Resistance of Implant Supported Metal Ceramic Crown: An in Vitro Study

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**Abstract:-**

- ***Purpose:***

**The aim of the study is to fabricate an implant crown for easy retrievability by designing a screw access channel(SAC) that does not compromises the fracture resistance of porcelain surrounding it.**

- ***Materials and Method:***

**The study was conducted on SACs of two coping designs of metal porcelain implant supported crown.The two group were (n10): Group I: metal ledge around SAC ; Group II: no metal ledge around SAC. The specimens were loaded universal testing machine with a cross-head speed of 2mm/min. Maximum values of loads at failure was recorded for each specimen. Mean values of fracture resistance for all groups were calculated and compared by using one-way ANOVA.**

- ***Result:***

**The mean value of load required to fracture for Group 2 i.e. 1822 N was significantly higher compared to Group 1 i.e 1077 N. The student t test revealed statistically significant difference between the two groups.**

- ***Conclusion:***

**The study concluded that SAC without metal ledge exhibited better porcelain fracture resistance as compared to SAC with ledge. Though both groups showed porcelain fracture resistance higher than normal masticatory force measured in the oral cavity.**

***Keywords:-*** *Screw Access Channel, Porcelain Fracture Resistance, Implant Supported Metal Ceramic Crown, Cement Retained Prosthesis, Screw Retained Prosthesis.*

## I. INTRODUCTION

In the last two decades , prosthodontic focus on osseointegrated implants has evolved immensely. The long-term survival rate of dental implant both functionally as well as aesthetically depends on various factors viz. implant designs, clinical techniques, dental materials and prosthetic components. One such factor of paramount importance is the type of prosthesis; which can either be screw-retained or cement-retained. Both have their advantages and disadvantages with their specific indications and contraindications.

The advantages of cement retained prosthesis (CRP) are the ease of working, passive fit, shorter lab procedures, economical. Cementing this prosthesis on implant abutments is similar to working on natural teeth as in fixed partial denture. This ease simplifies the restorations on implants even for beginners. The chances of CRP achieving a superior passive fit is better than a screw-retained prosthesis due to which the substantial strain within the restoration, implant, and investing bone complex can be avoided which usually occurs due to tightening of the ill fitting screw-retained restorations.[1,2] It is aesthetically pleasing as there is no screw access hole. The simplified fabrication reduces restoration cost as well.[3,4] The major disadvantages of CRP are retrievability and difficulty in removing excess cement from the margins once it is seated.[1,5] In the event of abutment screw loosening, porcelain fracture; the CRP has to be cut off to rectify the problem and fabrication of a new crown is often suggested which entails additional cost to the patient and fabrication of a temporary restoration for the esthetic zone.

Retrievability remains the prime advantage of a screw-retained prosthesis, although fabrication of screw retained prosthesis requires additional casting or milling process for abutment which complicates the fabrication process and the greater risk of screw loosening as compared to cement retained restorations.[6,7,8]

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Several studies have suggested various methods to incorporate the feature of retrievability in cement retained implant supported crowns by following methods:

- Provisional cement for cementation
- Lingual retrieval slot at the abutment/prosthesis interface.[9]
- Staining the occlusal surface of posterior restoration.
- Use of digital photographs or vacuum-formed templates to identify the position of screw for future reference.[10]
- Mc Glumphy E A et al. discussed the fabrication of single tooth implant supported restorations incorporating screw access hole on the occlusal surface for retrievability and this was cemented on the abutment like in a conventional cement-retained prosthesis.They called it "Combination implant crown". This technique overcomes the drawback of irretrievability associated with cement retained implant supported single crown restoration.[3]

The SAC compromises the continuity of porcelain on the occlusal surface and the effect of this discontinuity on porcelain fracture resistance is unclear as some studies mention that its presence compromises the porcelain fracture resistance of implant-supported metal porcelain restorations;[11,12,13] nonetheless an opposite view has also been reported.[14,15]

It is hypothesised that the design of SAC would affect the porcelain fracture resistance and based on this , the present study assessed the porcelain fracture resistance around the SAC using two designs i.e one incorporating vertical metal ledge around the hole and the other design with no metal ledge around the SAC of coping for metal ceramic implant supported single restorations. The study proposes the term "*Cement Retained Retrievable Crown*" (CRRC) for such crowns.

## II. MATERIALS AND METHODS

The present study was conducted in Department of Prosthodontics, Crown and Bridge of the college Ethical approval was obtained from the joint research and ethics committee of the college.

The study consisted of two groups which were divided into:

- *Group 1* **-** Control group; 10 samples with metal coping having 2.5 mm diameter of SAC with metal ledge of 2 mm in height and 1 mm width around screw access hole and layered with veneering porcelain.

- *Group 2* **-** Experimental group; 10 samples with metal coping having no metal collar around SAC 2.5 mm in diameter and layered with veneering porcelain.

For this , an implant analogue (Adin, Israel ) of dimension 4.2mm×13mm was connected to implant abutment (Adin, Isreal )of length 6 mm and tightened to a torque of 30 N/cm which was then embedded vertically in an acrylic resin block of 2.5 cm with the aid of a dental surveyor. (Figure1)

Each model was digitally scanned (Figure 2 ) and the two groups of metal coping (Figure 3, Figure 4) were designed by CAD using Exocad software and fabricated with a uniform thickness of 0.5 mm metal coping (Figure 5) through direct metal laser sintering technology (DMLS) with or without metal ledge around the SAC. (Dental Ceramist laboratory, Mumbai).

Porcelain applied to all specimens was standardized with silicone index of the waxed up mandibular molar crown for uniform size with dimensions; mesiodistal and buccolingual dimensions occlusally was 8.5mm. (Figure 6 )The crowns were luted with zinc-oxide eugenol cement and the SAC was restored with light cured composite resin.

Each specimen was loaded to vertical compressive load under Universal testing machine in Central Institute of Plastic Engineering and Technology (CIPET, Lucknow).The force applied to the specimen was perpendicular to the occlusal surface in the central fossa region of the restoration with a cross-head speed of 2mm/min. (Figure 7: Sample loaded under Instron) To simulate, the contact with the opposing tooth, the tip of the loading pin simultaneously contacted the triangular ridges of both buccal and lingual cusps of the crowns. The specimens were loaded till the catastrophic fracture occurred and values obtained at porcelain fracture was recorded for each specimen.

## III. RESULT AND OBSERVATIONS

The data obtained from the Table - 1 deduced that the mean fracture resistance for Group 2 (without metal ledge) i.e. 1822 N was significantly higher compared to Group 1 (with metal ledge) i.e 1077 N. The student t test revealed a statistically significant difference between the two groups at the 0.05 level of significance.

Table 1 Compressive Load Values for Group 1 (with metal ledge ) and Group 2 (without metal ledge)

| Sample | Group 1 | Group 2 |
|---|---|---|
| 1 | 1,011.1 | 1,962.3 |
| 2 | 1,354.6 | 1,923.7 |
| 3 | 938.9 | 1,863.1 |
| 4 | 818.4 | 1,148.6 |
| 5 | 1,061.3 | 1,940.6 |
| 6 | 1,088.5 | 1,823.6 |
| 7 | 1,066.4 | 1,925.7 |
| 8 | 986.2 | 1,823.5 |
| 9 | 1,468.1 | 1,945.2 |
| 10 | 980.6 | 1,865.3 |

## IV. DISCUSSION

The CRP have become increasingly common, mainly in patients requiring single crowns [16] and one of its disadvantages of irretrievability can be addressed by making SAC in the crown. But, there is little data in the literature regarding the effect of this channel on the properties of the prosthesis like retention, porcelain fracture strength, screw loosening. Researchers have conducted studies with SAC in CRP but with either one of the designs and no rationale has been proposed so far.

The study evaluated the two designs of SAC for porcelain fracture resistance in a single unit implant supported cement retained crown. The parameters incorporated in the study are as follows

- *SAC Design :*

SAC position: The SAC was in the center of the occlusal table as that directs the forces along the long axis of the abutment and implant.[17] This is an ideal situation ; though in a clinical situation , this may not be the alignment.

- *SAC Diameter :*

Conventional abutment screw measures 2 mm in diameter, 7.8 mm in length, and 0.4 mm in screw thread pitch.[18] The SAC in the study was kept slightly larger i.e. 2.5 mm 13 than the screw head diameter for easy access. With this diameter, about 2- 3 mm of crown around the periphery was left intact which is about 70% of the occlusal table in group 2 and less than 50% in group 1 for the vertical ledge was 1mm in thickness. The size of occlusal access is determined by the retaining screw diameter which, for larger implants (for example, in the posterior regions of the mouth), obliterates a large portion of the occlusal table i.e. about 50% of the occlusal table in molars and 75% in premolars.[19]

- *Ledge Height :*

Group 1 had vertical ledge and group 2 had no ledge around SAC.[20] The 2 mm vertical ledge on the coping (Group 1) ensured sufficient thickness of ceramics[21] in the central fossa for adequate porcelain strength and also provided lateral support to the porcelain around the SAC.The recommended procedure for preparing the coping for a PFM crown is to receive the porcelain on a thin facial cervical collar made of metal[22] for it serves as a truss or a framework to strengthen the casting and to resist deformation during the ceramic firing cycles.[23] The ledge design (group 1) around SAC of metal coping was logically based on the fact that porcelain when supported by metal exhibits better fracture strength as the unsupported porcelain in Group 2 when subjected to an occlusal force would create a lever arm or cantilever ; capable of amplifying the load on the crown components around the screw access hole ; though no metal ring in group 2 design would make the crown look aesthetic.

- *Ledge Thickness:* 1 mm thick metal ledge around SAC was designed12,15, 17
- *Metal Coping:* The thickness of the metal coping was designed for 0.5 mm for receiving the porcelain layer.[24,25]

Direct metal laser sintering technique was used to standardise the thickness and shape of metal coping [24,26] and the dimensions of the SAC.

- *Veneering Porcelain :*

Silicone index was used to standardise the thickness of the ceramic layered over metal coping and the shape and size of the metal ceramic crown for both the groups.[12,13,15]

- *Luting Cement:*

Temporary luting cement was used for luting the crown for the axial height of abutment was optimum for good retention[11,27] and coping with DMLS technique provided good fit . With all these prerequisites , temporary luting cement is advisable in clinical situations as also for the temporary cement is easy to remove ; thus, avoiding periimplantitis when margins are subgingival. The type of cement does not affects the porcelain fracture resistance significantly even for CRP with a SAC[11] and fabricating cement-retained implant prostheses with screw access does not compromise or reduce the retention of the crowns when compared with screw retained prosthesis.[21]

- *Group 1 Versus Group 2:*

The mean porcelain fracture resistance for Group 2 (without ledge) i.e. 1822 N was significantly higher compared to Group 1 (with ledge ) i.e 1077 N.

Only one such study with similar groups has been reported in the literature.[15] Their results are inconsistent with the results of this study. It has reported no statistically significant difference between the CRP groups with SAC and CRP with no SAC ; the values of CRP were less than that of CRP with SAC [15] which is unlike the comparatives mentioned in the literature for CRP with no SAC when compared to screw retained prosthesis.[11,12] The lower values of group 1 as compared to group 2 could be attributed to the reduced amount of porcelain around the SAC periphery in group 1.This indicates that the amount of peripheral porcelain around SAC affects the porcelain fracture strength irrespective of presence of metal collar around SAC to support the porcelain.

Almost similar values of porcelain fracture strength (1770 N) for group 2 have been reported by another study[12] though the comparative groups are different.

The values of porcelain fracture strength observed in the study for CRP with or without SAC have been in the range of values reported in the literature.[12,14]

On the other hand, studies have reported lesser porcelain fracture strength [28,29] as compared to the present study. This could be due to the difference in the crown size i.e. use of the cylinder size of a small molar instead of that of a large molar. A larger size provides a larger metal and porcelain bonding surface area, which would be expected to increase the fracture resistance strength as was observed in the present study. [30]

The variability amongst the results of different studies could be due to multitude of factors like specimen fabrication technique, size of specimen , implant diameter used, size of SAC, sealing the channel or not sealing it, placing a screw in the abutment or not, cementing the prosthesis or not, type of luting cement, the type and cycles of force used for loading, the area on which the force was applied, change of actual abutment with every testing sequence, testing the specimen on a die and many more.

In the study, the porcelain fractured at the value of 1800 N which is almost 2-3 times greater than the biting force. During normal functioning of the oral cavity, the porcelain failure in such crowns should not be the area of the concern; as the bite force of the Jordian population - ranges from 573.42 ± 140.18 N [31] ; in Indonesian population it was reported to be 806.23 ± 324.83 [32] ; in Indian subjects is 372.39 ± 175.93 N.[33]

The bite force based on various studies is in the range of 300-1000 N ,thus, it can be safely mentioned that in this study that the porcelain fracture strength around the screw access hole has been found to be more than the maximum biting force.

Though it has even been found to be as high as 800N [34] -1200 N in humans [35] ; so patients with a high bite force may have an increased risk for component fracture.[36]

The SAC can be restored for posterior restorations by either utilizing a silicone plug and resin opaque [37] or a pressed ceramic plug [38]; this would blend the screw access hole with the restoration but with a metal ring around the collar this would not be possible.

CRP with SAC has an increased risk of porcelain fracture when compared to conventional CRP. But due to the feature of retrievability , this design of CRRC should be considered in the treatment plan after a thorough evaluation of factors like gender of the patient, bite force, opposing dentition, implant diameter , screw diameter, mesiodistal and buccolingual space of single crown to be replaced, abutment and implant platform margin.

Despite the meticulous protocol followed in the current investgation to standardize the fabrication of the specimens, it was difficult to control 3D slumping of porcelain during the firing cycle. These potentially introduced inaccuracies might have been responsible for the large standard deviation reported in this study. (Table -2) Therefore, every effort should be exercised to produce accurately standardized experimental specimens.

The limitations in the present study are smaller sample size, samples were not thermocycled , use of single static force to load the specimens whereas in oral cavity the temperature , pH variations , dynamic load on the restoration may contribute to fracture due to fatigue loading. The future scope of the study involves testing of larger sample sizes under physiologic fatigue loading with sharp focus on standarization of porcelain application.

## V. CONCLUSION

Within the limits of the study, following conclusions can be deduced:

- Screw access hole with no supporting metal ledge exhibited better porcelain fracture resistance as compared to metal collar margin.
- The amount of peripheral porcelain around the SAC significantly affects the porcelain fracture resistance.
- The porcelain fracture resistance exhibited in both the groups were quite higher than the normal masticatory force experienced in the oral cavity.

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**LIST OF FIGURES**



Fig 1 Implant Analogue with Abutment in the Acrylic Block

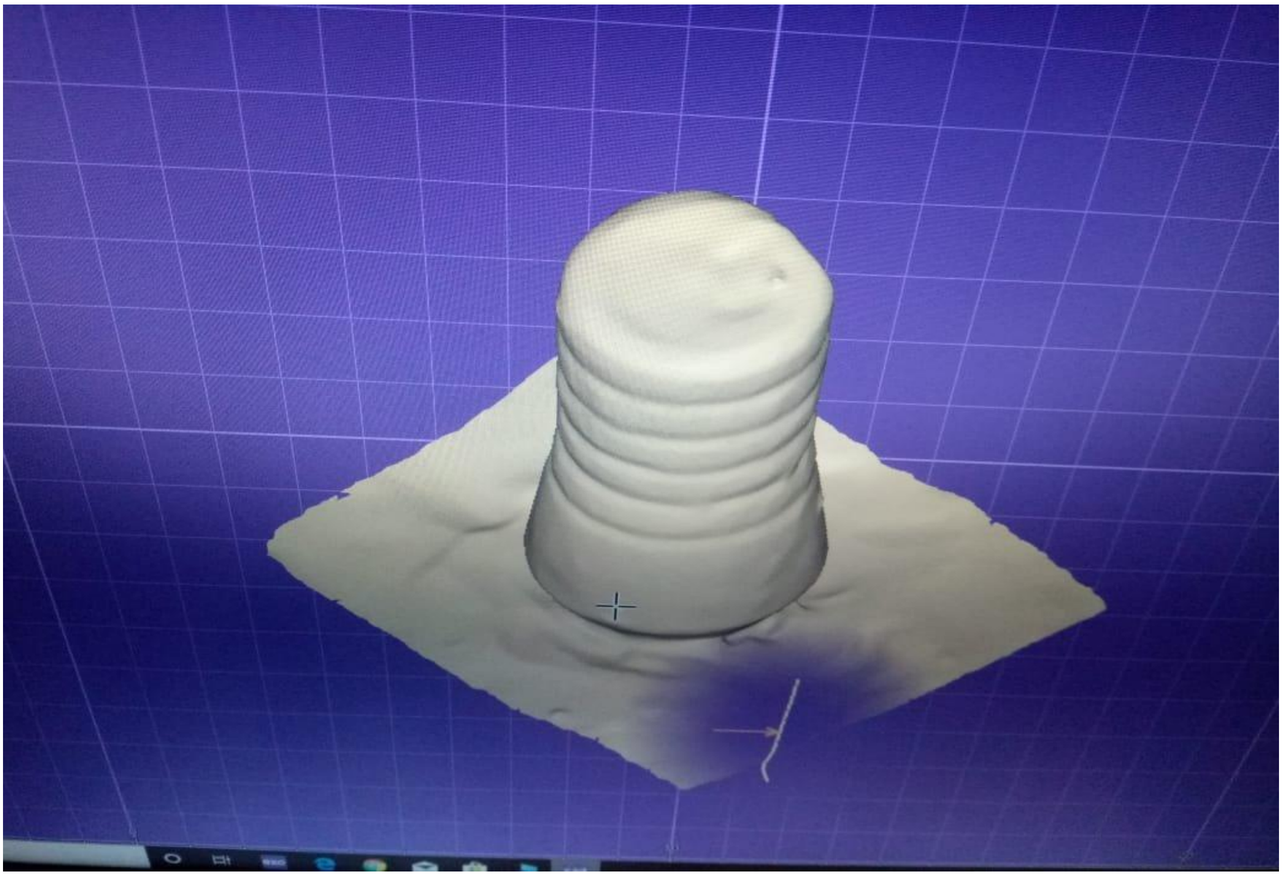

Fig 2 Scanned Image of Implant Abutment

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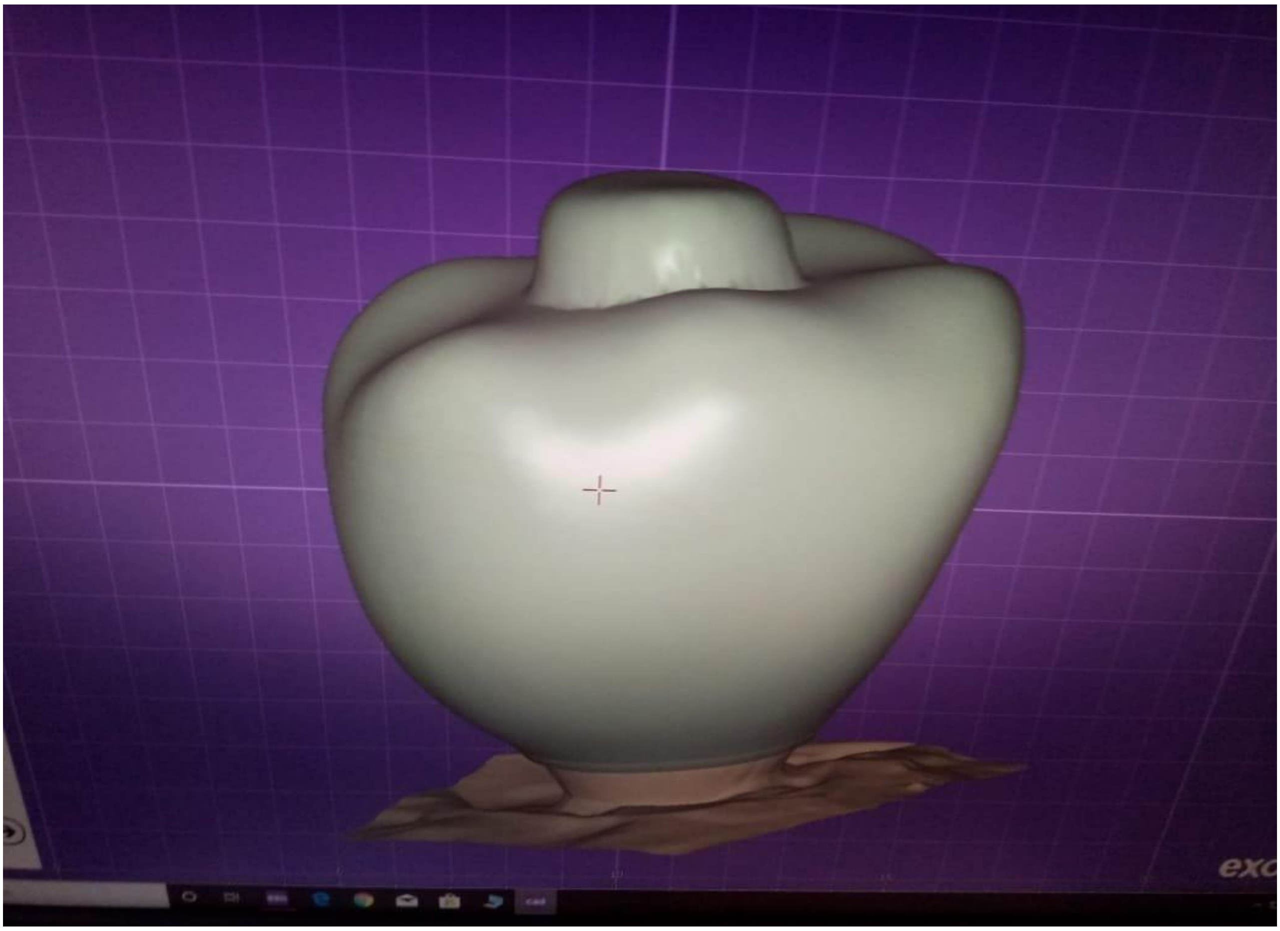

Fig 3 CAD of Group I Metal Coping

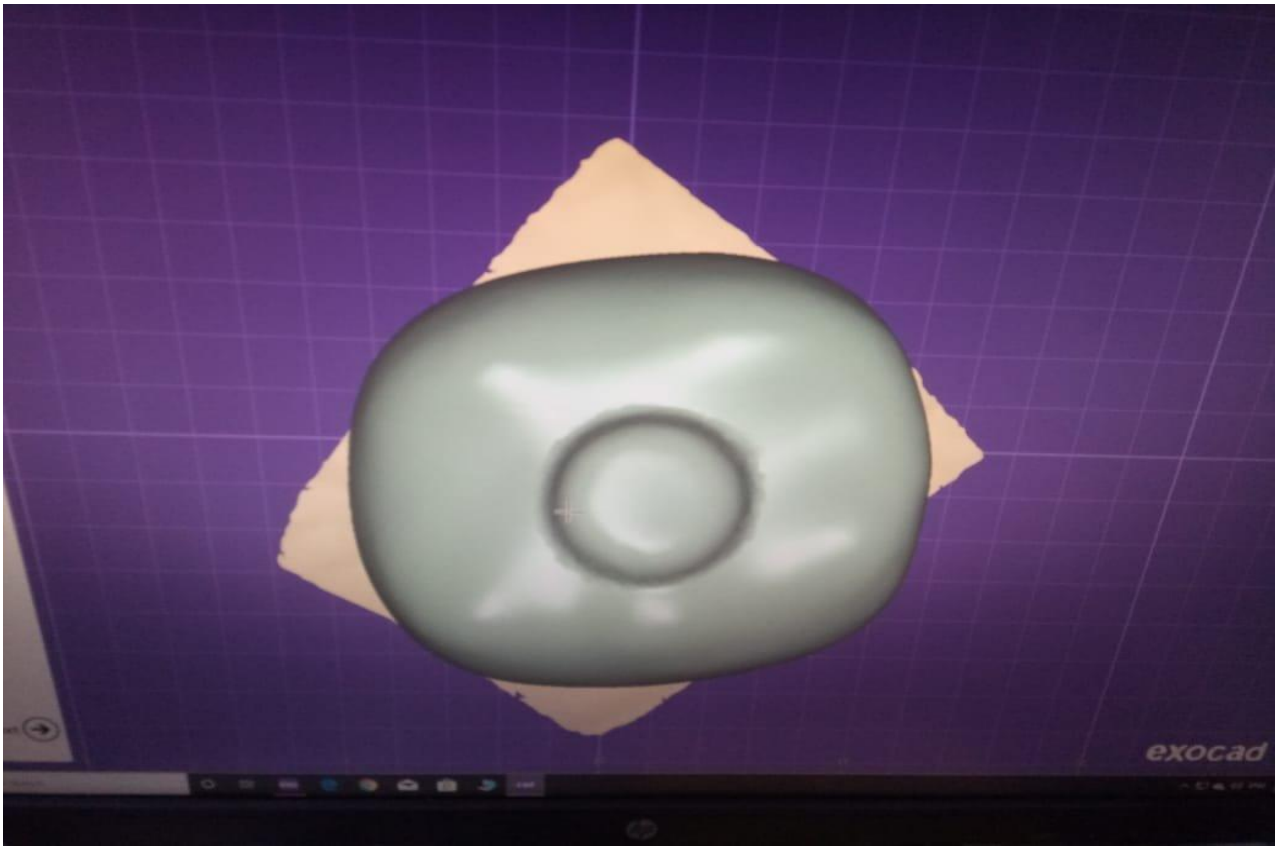

Fig 4 CAD of Group II Metal Coping

Fig 5 DMLS Copings of Group I and II

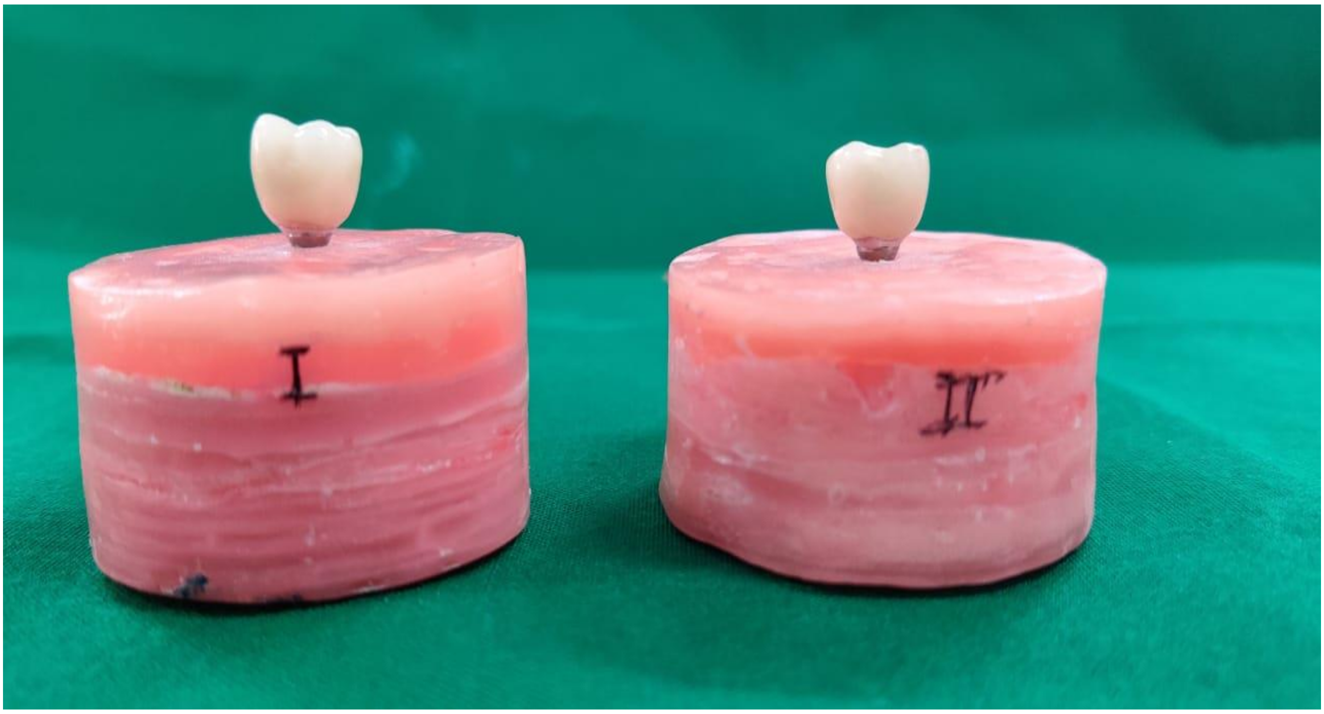


Fig 6 Crown after Porcelain Application

Fig 7 Fractured Specimen Under Instron Machine