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COMPARISON OF FAILURE LOADS OF METAL CERAMIC CROWNS WITH TWO DIFFERENT MARGINS-AN IN-VITRO STUDY.

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ABSTRACT:

Objective:- This in vitro study compared the load necessary to cause porcelain failure on traditionally fabricated metal-ceramic crowns cemented to metal tooth analogues with two different types of margins.

Methods :- A sample size of 40 specimens were selected and divided in to two groups with 20 sample each. All the crowned specimens were embedded in autopolymerising resin. The acrylic resin should be approximately at 2 mm distance from the margins of prepared crowns. All polymethyl methacrylate resin blocks were ground flat to ensure that each specimen is secured and in correct alignment, when compressive forces were applied to the lingual-incisal line angle, at 130° to the long axis of the specimen until catastrophic porcelain fracture occurs.

Results:-The load at which porcelain fracture occurred on crowns fabricated with shoulder margin was 1742N and the load at which porcelain fractured occurred on crowns fabricated with chamfer margin was 946N.

CONCLUSION:- Astatistically significant difference was found between the loads at which porcelain from crowns with porcelain margins was fractured and crowns with metal collar margins was fractured($p< 0.01$), with porcelain margins being the highest value.

Key Words: Metal ceramic, Shoulder Margin, Chamfer Margin, Failure Load

Introduction:

The metal-ceramic crown is currently the most popular complete veneer restoration in dentistry because it derives its esthetics from the highly translucent, natural appearance of porcelain and its strength from a metal substructure.[1] The metal-ceramic crown has gone by a variety of names since its introduction to dentistry nearly four decades ago. It was called, at different times and in different parts of the U S, a “ceramco crown” a “porcelain veneer crowns” “porcelain fused to gold” as well as porcelain fused to metal.[2]

Porcelain-fused-to-metal crowns are produced with a variety of marginal designs to achieve the best fit and appearance. On the basis of early dental literature, it was apparent that many persons considered tooth preparations and finish lines as important factors that affect the clinical longevity of porcelain jacket crowns and porcelain fused to metal crowns.[3]The inadequate quality of tooth preparation seems to be a common threat contributing to metal ceramic crown failure. While adequate tooth reduction is necessary to provide sufficient space for the metal and ceramic to satisfy both mechanical requirements and esthetic, such a reduction should be accomplished without endangering the pulp or supporting periodontal structures.[4]

The most popular designs of finish lines also seem to be variants of the shoulder or chamfer.[2]Among these finish lines shoulder finish lines were advocated because of increased

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restoration strength, porcelain bulk and marginal strength, and fabrication accuracy. An ideal finish line should allow for optimum thickness of both metal and porcelain to satisfy the mechanical and esthetic requirements.[3]

The shoulder has long been the finish line of choice for the all-ceramic crown as well as metal ceramic restoration. The wide ledge provides resistance to occlusal forces and minimizes stresses that might leads fracture of porcelain. It produces the space for healthy restoration contours and maximum esthetics. However, it does require the destruction of more tooth structure than any other finish line. The sharp, 90° internal line angle associated with the classic variety of this finish line concentrates stress in the tooth and is conducive to coronal fracture. The preferred gingival finish line for veneer metal restoration is the chamfer. This finish line has been shown experimentally to exhibit the least stress, so that the cement underlying it will have less likelihood of failure.[2]

Marginal fit and adaptation are crucial for the prognosis of restorations including metal-ceramic crowns. Any marginal discrepancy can lead to micro-leakage, marginal discoloration, secondary caries and eventually failure of restoration. Various factors including ceramic firing effect, curvature of finish line and type of cement on the effect of the marginal adaptation of metal-ceramic crown restorations have been reported.[5]

The porcelain fused to metal restorations are unavoidably subjected to mechanical stresses due to constant masticatory mechanism and are susceptible to cyclic mechanical fatigue. Clinically, accumulation of microstructure damage during mastication may induce a catastrophic failure.[6] This study was done in order to test the strength of the metal ceramic restoration in two different margins.

METHODOLOGY

A total of 40 samples were prepared and grouped under two categories. Each group contains of 20 samples (Group- A and Group-B).

Group A – 20 samples of the Metal Ceramic Crowns fabricated with Porcelain facial margins on labial surfaces.
Group B- 20 samples of the Metal Ceramic Crowns fabricated with metal facial collars on labial surface.

A resin maxillary left canine analogue was prepared for a metal-ceramic crown, with a 1.5 mm shoulder on the facial surface with flat-end tapered diamond that was carried to the mid-proximal region both mesially and distally and was blended to a chamfer finish line on the lingual surface with torpedo bur, values are measured with the help of digital vernier callipers. The lingual reduction was approximately 0.8 mm, conforming to the anatomic concavity of the lingual surface. With a cingulum wall approximately 2 mm high, with a taper to the facial axial surface of approximately 15 to 20° with the help of toolmakers microscope (Fig 1a). The facial shoulder was initially prepared with a 90° angle to the cavosurface, for a crown with the porcelain facial margin. A mould of this tooth was made with polyvinyl siloxane impression material (Fig 1b), wax patterns were made from this mould was cast with the nickel-chromium alloy. The facial shoulder of the prepared dentoform tooth was then re-prepared to a 135° angle to the cavosurface (Fig 1c), for a crown with a metal collar margin. This was similarly duplicated and reproduced 20 times with the same nickel chromium alloy.

Two coats of die spacer were applied within 1 mm of the finish line. Wax patterns for copings were developed directly with green dip wax technique. Green inlay wax was used to establish lingual surface contours, facial metal collars, and final marginal adaptation of the samples. The wax patterns were invested in phosphate bonded investment and cast with the nickel chromium alloy as the metal tooth analogues, with an induction casting machine. The irregularities in the casting were removed with small rotary instruments and air abraded with 50 μm aluminium oxide. One group of copings retained the 0.4 mm wide metal collars, while the other group had metal removed to the gingiva-axial line angle to accommodate the porcelain facial margin. The veneered surfaces of the copings were finished with abrasive wheels to obtain a uniform thickness of 0.4 mm, and the castings were cleaned with a 50 μm aluminium oxide air abrasive. Surfaces that require porcelain application were rubber wheeled and steam cleaned. The porcelain build-up for both groups of castings was initiated with two applications of opaque porcelain. Shoulder porcelain was applied to the group of castings with porcelain facial margins, by using the direct lift technique. Shoulder porcelain was brushed to the gingival margin and was carved with a concavity designed to eliminate over contouring the final restoration. This layer was dried and fired. A second, corrective layer of shoulder porcelain was applied and fired. Dentinal porcelain was applied over the opaque and shoulder porcelain. it was also applied over the opaque crowns with metal-collar margins.

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This application was cut back in the standard fashion, and Incisal porcelain was added. Crowns were fired and then contoured with abrasive wheels. Measurements were made to ensure that the total thickness of porcelain and metal comes after 1.5mm. The porcelain was glazed. Porcelain application and condensation was standardized as much as possible within the confines of usual laboratory techniques for fabricating metal-ceramic crowns.Thus, the crowns for both groups are fabricated (Fig 2a & 2b).

The internal surface of the castings and the surface of the metal analogues were air abraded with 50μm pure aluminium oxide. The metal analogues were placed in wax blocks having an angle 130° with the help of protractor and custom-made metal block and followed by dewaxing and packing with heat cure acrylic. The acrylic resin should within 2 mm of the margins of crowns (Fig 3a). All polymethyl methacrylate resin blocks were ground flat to ensure each specimen would be secured and in correct alignment when compressive forces were applied. Finished crowns were cemented with a glass ionomer cement to the tooth analogues and allowed to set for 24 hours. Specimens were tested on an Instron testing machine (Fig 3b). The load was directed at the lingual-incisal line angle until catastrophic porcelain fracture occurs. This position was selected to reproduce the occlusal forces directed to a maxillary canine. Each specimen was checked against a matrix to ensure identical angles were used during each trial. A round diameter rod was used to load the artificial crowns, with the centre of the rod in contact with porcelain surfaces. A crosshead speed of 2.5 mm per minute was used to test the failure load of the samples and obtained values are analysed. Failure of the specimens for each group is observed as shown in Fig 4a & 4b.

Results:

Student paired 't' test was done and the results of the study for two groups were as follows:

GROUP A:

This group includes the metal Ceramic Crowns fabricated with porcelain facial collars on labial surface. The total mean fracture load was 1742 Newton's with standard deviation 38.819. The standard error of mean was 8.680.

GROUP B:

This group includes the Metal Ceramic Crowns fabricated with metal facial collars on labial surface.The total mean fracture load was 946.100 Newton's with standard deviation 77.710.The standard error of mean was 17.376.

Table-1: Mean break load values of both the groups.

	GROUP	N	MEAN	STD. DEVIATION	STD ERROR MEAN	t-VALUE	p-VALUE
Break Load	Group- A	20	1742.000	38.819	8.680	40.975	0.000
	Group-B	20	946.100	77.710	17.376		

Discussion:

The word "ceramics" is derived from the Greek word "keramos" meaning "burnt stuff".*Ceramics* is defined as non-metallic and inorganic, man made solid objects formed by baking new materials (minerals) at high temperatures.[7]

The porcelain fused to metal (PFM) restorations, has become increasingly popular over the past 10 to 15 years due to their cosmetic appearance, durability and versatility of use for both single restorations or multiple restoration.[8]The first successful porcelain fused to metal system was used early in 1960s, from which there has been increasing demand for ceramic restorative materials. As recently as 1990, of the estimated 35 million crowns placed by private practice dentists, more than 71 percent had porcelain as one of the components. This popularity may be the result of porcelain esthetics. Porcelain is the most natural-appearing synthetic replacement material for missing tooth substance. It is available in a range of shades and translucencies for achieving life like results. Historically, strength concerns compromised some of the beauty of porcelain crowns. Because of the relatively low tensile strength and brittleness of the porcelain, it has been generally fused to a metal substrate to increase resistance to fracture. The aesthetic demands in the region of the labial margin,

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combined with the strength of conventional metal ceramic restorations shows the increasing popularity of metal ceramic restorations.[2]

The indications of metal ceramic restorations are mainly

a) In the cases of Para functional mandibular activity where an aesthetic restoration is essential, where lingual clearance of less than 0.8 mm is present after tooth preparation.
b) Teeth requiring fixed splinting or being used as bridge abutments, in all posterior teeth where full coverage is needed for aesthetic reasons, where gold occlusal surfaces are required.
c) Extensive tooth destruction as a result of caries, trauma or existing previous restorations that preclude the use of more conservative restorations.
d) When there is need to connect the occlusal plane or recontour axial surfaces.

The Contraindication are

a) The use of the metal ceramic crowns in adolescent teeth where minimal tooth preparation is essential, in adult teeth enamel wear is high and there is insufficient bulk of tooth structure to allow room for metal and porcelain.
b) Anterior teeth where esthetics is of prime importance e.g. light shades or very translucent teeth and patients with active caries or untreated periodontal disease.

The concept of reducing metal on the shoulder was developed to avoid the darkening effect of metal on the adjacent gingiva[9]. The porcelain facial margin crown described by Prince et al., has been one of the most popular metal ceramic crown designs.[10] The improvements of shoulder porcelains have resulted in materials that are similar to body porcelains in shade and texture and further reduced the metal framework substructure on the shoulder. [9]

The metal-ceramic restoration consists of a metal substructure supporting a ceramic veneer that is mechanically and chemically bonded to it. The chemical component of the bond is achieved through firing (baking). Porcelain powders of varying composition and colour are applied and fired to produce the desired appearance. The first ceramic layer, the opaque**,** masks the dark metal oxide and is the primary source of colour for the completed restoration.[2]

Optimal marginal fit of dental restorations is essential for their long-term success in the oral cavity. It has been suggested that a marginal gap of 120 microns represents the maximum clinically acceptable gap size. The ceramometal restorations were developed to reduce these limitations by providing a metal substructure to reinforce the porcelain and facilitate superior marginal integrity and the best marginal fit.[11] Different marginal designs for metal-ceramic crowns have been proposed. Knife-edge, flat shoulder, 135^0shoulder (long bevel, sloped shoulder), flat shoulder with 45◦ bevel, chamfer, and deep chamfer with bevel are some of the most frequently used finish line designs for complete veneer restorations. The most popular designs of finish lines also seem to be variants of the shoulder or chamfer.[2]

Among these finish lines shoulder finish lines were advocated because of increased restoration strength, porcelain bulk and marginal strength, and fabrication accuracy. An ideal finish line should be present for optimum thickness of both metal and porcelain to satisfy the mechanical and esthetic requirements.[3]

The shoulder has long been the finish line of choice for all-ceramic crowns as well as metal ceramic restorations. The wide ledge provides resistance to occlusal forces and minimizes stresses that might leads to fracture of porcelain. It produces space for healthy restoration contours and maximum esthetics. However, it does require the destruction of more tooth structure than any other finish line. The sharp, 90° internal line angle associated with the classic variety of this finish line concentrates stress in the tooth and is conducive to coronal fracture. The preferred gingival finish line for veneer metal restoration is the chamfer. This finish line has been shown experimentally to exhibit least stress, so that the cement underlying will have less likelihood of failure.[2]

In collarless metal ceramic crown, the facial porcelain margin eliminates the unpleasant metal collar due to increased thickness of porcelain at the gingival margin.[12]

David A. Felton et al and Brien R. Lay et al conducted studies and showed that marginal precision fit of metal ceramic restorations is significantly better with a porcelain –butt margin than with a feather edge metal margin.[10]

Shillingburg et al concluded that the shoulder and the shoulder with the bevel type of margin produced the best fit with no significant distortion while chamfer type of margin even with the bevel resulted in a poor fit with significant distortions and unesthetical appearance.[13]

Comparison of failure loads of metal ceramic crowns with two different marginal designs was evaluated. One group included the metal ceramic crowns fabricated with porcelain facial margins on the labial surface, and the other group included metal ceramic crowns fabricated with metal facial collars on labial surface.

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Sikka Swathi, R-Chowdhary and P.S.Patil et al., conducted a study to compare fracture strength at margins of metal-ceramic crowns with different marginal configurations shoulder and shoulder with bevel with 0.0 mm, 0.5 mm, 1.0 mm and 1.5mm. Maxillary right canine typhodont tooth was preferred to receive metal ceramic crown with shoulder margin and duplicated to the 20 metal tooth analogues. Similarly, same teeth re-prepared with shoulder bevel configuration. They concluded that ceramo-metal crowns with shoulder margins fractured under higher forces than those with shoulder bevel margin, irrespective of framework reduction.[12]

Penwadee Limkangwalmongkol conducted a study, compared the precision fit of metal ceramic crowns with two margin design (internally rounded shoulder preparation & butt margin on the buccal aspect and a feather-edge metal margin on the lingual aspect). Various techniques for fabricating metal ceramic restorations based on different metal coping designs include metal collar, collarless and porcelain butt margin. Labial metal collar is found to be the ideal design in terms of marginal seal, periodontal health and rigidity during cementation; however, the metal collars are difficult to conceal in the shallow crevice or with a thin or translucent gingival margin. Reduction of the labial metal collar known as triangular formation or feather edge permits opaque layer and porcelain to cervical area of tooth preparation. However, this design appears attractive but technique sensitive and difficult to achieve without over countering the cervical aspect or exposing the opaque layer.[11]

Konstantions X michalatius et al conducted a study to evaluate fracture resistance of metal ceramic restorations with two different margin designs after exposure to masticatory simulation and compare the fracture resistance of metal ceramic restorations with metal margins and with circumferential porcelain margins after exposure to masticatory stimulation with a total of 600,000 loading cycles in the aqueous environment. He reported that there was a statistically significant difference among the tested group ($p<0.001$) and the metal ceramic restorations with metal margins required significantly greater loads to fracture than the metal ceramic crowns with circumferential porcelain margins. Metal ceramic crowns with metal margins demonstrated cohesive failure in the porcelain body, while Metal ceramic restoration with circumferential porcelain margins showed combination of both adhesive and cohesive failure. He concluded that in clinical implications metal ceramic restorations with metal margins are prepared over metal ceramics crown with circumferential porcelain margins when the heavy occlusal loads on para-functional activity are anticipated.[14]

The kind of the finish line is one of the factors that influence the marginal adaptation of crowns. For metal-free crowns, the two predominant kinds of finish lines suggested by the literature are the round shoulder and the deep chamfer.[15]

Carlo Monaco in his study found that no significant difference was found in terms of load-to-fracture between teeth restored with all-ceramic and metal–ceramic single crowns. Although the control group showed a tendency toward lower marginal adaption, no significant difference was detected between all-ceramic and metal–ceramic single crowns.[16]

The CAD/CAM fabricated zirconia crowns demonstrated a better accuracy of fit when compared to metal-ceramic crowns fabricated by conventional technology.[17]

Conclusion:

This in vitro study was carried to compare the failure loads of metal ceramic crowns with two different margins namely (chamfer) porcelain margin and (shoulder) metal margin, and the following conclusions are drawn from the study: -

- The load at which porcelain fracture occurred on crowns fabricated with shoulder margin was 1742N.
- The load at which porcelain fractured occurred on crowns fabricated with chamfer margin was 946N.
- There was a statistically significant difference found between the loads at which porcelain from crowns with porcelain margins was fractured and crowns with metal collar margins was fractured($p< 0.01$), with porcelain margins being the highest value.
- The load required to fracture porcelain from crowns with porcelain margins was greater than crowns with metal collar margins.

FIGURE LEGENDS:

Figure-1 (A): Measuring the Taper of Preparation with Help of Toolmaker's Microscope; (B): Polyvinyl Siloxane Impression of Prepared Tooth Prepared with Shoulder Finish Line 90°; (c): Polyvinyl Siloxane Impression of Prepared Tooth Prepared with Chamfer Finish Line135°

Figure-2:Group A – Metal Ceramic Crowns with Porcelain Facial Margins on Labial Surfaces. Group B - Metal Ceramic Crowns with Metal Facial Collars on Labial Surface.

Figure-3 (A): Metal Analogues in Wax Blocks Having an Angle of 130° with Help of Protractor and Custom-Made Metal Block; (B): Testing of Specimens on Instron Testing Machine

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Figure-4 (A): Fractured Specimen of Group –A; (B): Fractured Specimen of Group- B

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ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

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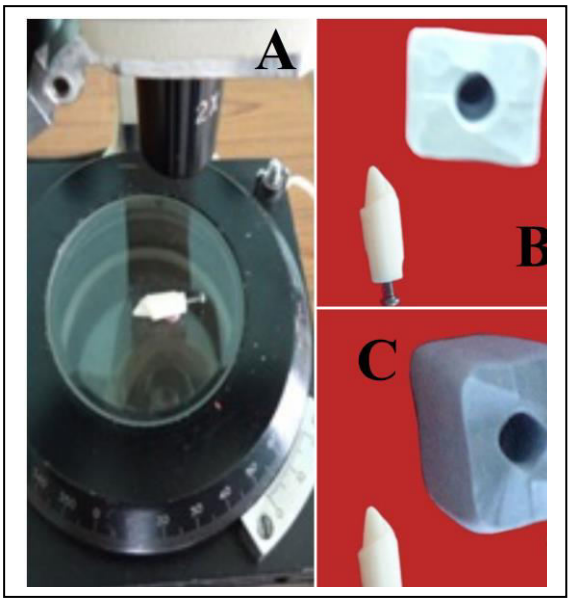
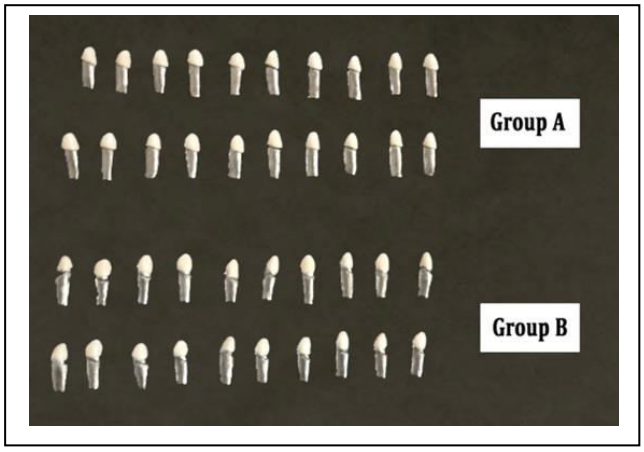


Figure-2:Group A – Metal Ceramic Crowns with Porcelain Facial Margins on Labial Surfaces. Group B - Metal Ceramic Crowns with Metal Facial Collars on Labial Surface.



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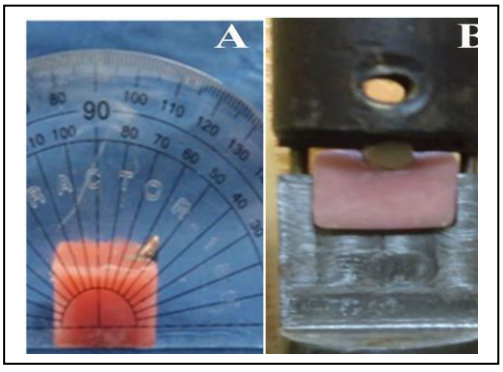

ISSN: 0975-3583, 0976-2833 VOL 12, ISSUE 03, 2021

Figure-4 (A): Fractured Specimen of Group –A; (B): Fractured Specimen of Group- B