Comparison of Marginal Fit between Collarless Metal Ceramic and two all Ceramic Restorations

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Abstract: Marginal adaptation of the crown is a crucial factor in determining its clinical acceptability. Crown fit as judged by marginal seal influences the longevity of the cast restorations to a great extent. Metal ceramic restorations have been implicated for the discoloration in area of labio-gingival margin. Attempts to rectify this, by altering the design of metal frame works as eliminating the labial metal collar with substitution with shoulder porcelain may improved the esthetics. Excellent esthetics and superior biocompatibility of all-ceramic restorations making them the best alternative to conventional metal-ceramic restorations**.**
Objectives: This study measured and compared the precision of fit of Collarless metal-ceramic crowns and two types of all ceramic crowns, by measuring the gap dimension between the crowns margin and finishing line of the prepared tooth**.**
Materials and Methods: Thirty samples were prepared for this study. Divided into 3 groups (N=10): *Group A*, (n=10) metal ceramic with porcelain collar, Group B, (n=10) IPS Empress and Group C, (n=10) IPS Empress CAD. A standardized 2 Stainless Steel dies were machined. The first die for all ceramic samples, and the second for the collarless metal ceramic samples. The Stainless Steel master dies were duplicated with polyether impression material using custom made trays and these were poured with type IV improved stone. For IPS Empress crowns (Group B), wax patterns were made by soft inlay wax over the stone dies. The wax patterns were sprued and invested and casted in special pressing furnace. After pressing, recover the restoration by airborne particle abrasion, remove the sprue, and refit it to the die. For IPS Empress CAD (Group C), Cerec in lab CAD/CAM system (Sirona, Bensheim, Germany)was used for machining the appropriate ceramic block In order to obtain the final crowns. After that crowns were covered with IPS Empress Universal Glaze and fired in a program at CS Furnace to 770ºc. The marginal fit of crowns was evaluated with optical micro scope.
Results: The results showed that, IPS Empress CAD group C revealed the poorest marginal integrity with 99. 4 ±0.53 µm. IPS Empress Group B was next in line with 72. 8±0.71 µm. Compared to this first group of all-ceramic restorations, the result of 32. 5±0.74 µm obtained with conventional metal ceramic collarless restorations was clearly better.
Conclusion: Group C metal ceramic collarless crowns had highest marginal fit when compared with Group B and Group A. Use of Metal ceramic crowns with shoulder porcelain has the potential to improve the esthetical of the restoration especially at marginal area without significantly affecting its marginal fit
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Key words: Collarless -metal ceramic restoration, direct lift technique, subgingival margin, two planes Reduction.

1. Introduction

Metal ceramic crown has always been the most popular complete veneer restoration in dentistry, because it derives its aesthetics from the highly translucent natural appearance of porcelain and the strength from the metal substructure, Gardner et al., (1997); Ulusoy and Toksavul (2002).

Esthetics with porcelain fused to metal restoration in the anterior region can be adversely affected due to the inadequate teeth preparations and design of the prosthesis. Porcelain fused to metal (PFM) crowns may sometimes be associated with greyish discoloration at the cervical third of the restoration due to thinness of porcelain in this area and in the adjacent tissues due to reflection of light meeting the opaque substrate of PFM restoration and thin gingival tissues, Raptis (2006).

This is an optical effect that is more noticeable when the upper lip is not retracted and has also been described in the literature as umbrella effect, Magne et al., (1999).

In an attempt to satisfy the esthetical demands of the patient and maintain the health of the periodontium, clinician's modified the margin of the metal ceramic crown. Some thinned the facial collar of metal significantly in an attempt to visually eliminate it. But Donovan and Prince (1985) found that these margins could distort when the porcelain was fired, greatly compromising the fit of the restoration. Others covered the facial collar of metal with porcelain in an attempt to hide it from view. This modification cannot be done without over contouring the restoration which can lead to gingival irritation Preston, Preston (1977). One method of eliminating a metal collar is to use the very esthetic porcelain jacket crown restoration. Given these findings, an alternative would be to fabricate the metal ceramic restoration without the labial margin restored in metal -- have a butt-joint

of porcelain as the gingival margin. Such an approach would combine the strength of the metal ceramic crown with the esthetics of the porcelain jacket crown at the margin Dykema et al., (1986). Currently, this restoration is known as the porcelain labial margin metal ceramic restoration or collarless metal ceramic crowns.

Researchers have shown that metal collars diminish light transmission into the adjacent tooth tissue, causing darkened appearance of both root surfaces and gingival, O'Boyle et al., (1997). Hence, the choice of restoration would be, that has the structural advantages of the metal ceramic restoration and the aesthetic qualities of the all ceramic crown, especially on the cervical third These requirements have led to the development of facial porcelain margin in metal ceramic crowns, also known as collarless metal ceramic crown

In collarless metal ceramic crowns, the facial porcelain margin eliminates the unpleasing metal collar, due to increased thickness of porcelain at the gingival margin. Plaque retention is reduced due to highly glazed body porcelain at the margin. As it is not necessary to hide a metal collar, periodontal health is further promoted by minimal extension into the gingival sulcus, Behrend et al., (1982).

The advantages of making a collarless metal ceramic restoration are improved esthetics and easy plaque removal when the gingival tissues are in contact with highly glazed porcelain as compared to highly polished metal, Matsumoto et al., (2001). Disadvantages are difficulties during fabrication, where marginal adaptation is not as good as that of cast metal, chances of fracture of unsupported margin during evaluation or cementation, extra lab steps that require more time and, therefore, are more costly, Rosenstiel Land Fujimoto (2006).

Lab procedure included the fabrication of metal substructure in the usual manner, the framework was shortened by 1. 5mm labially and opaque was applied and fired. The die was coated with cyanoacrylate resin, which acts as a sealant of porous stone. Porcelain release agent was coated to the shoulder of the prepared die as it results in easy separation of the restoration. The porcelain was condensed directly onto the die and opaque porcelain and fired. A second bake is usually necessary for better margin adaptation, Rosenstiel Land Fujimoto (2006).

Various studies have been done on collarless metal ceramic crowns with different marginal configurations and different framework reduction, which have been checked for fracture strength under vertical load, Prince et al., (1983). However, occlusal forces acting on the anterior teeth are not generated exactly at 90-degrees, but at an angle, Ulusoy and Toksavul (2002). So to check for the durability of these collarless metal ceramic crowns in vivo, we need to evaluate these restorations under the load at particular angle, which the tooth encounters in oral cavity.

Study was carried out to evaluate the effect of five different metal framework designs on the fracture resistance of the metal-ceramic restorations. IT was concluded that**,** the maximum load required to fracture the test specimens even in the groups without the metal collar was found to be exceeding the occlusal forces. Therefore, the metal frameworks with 0.5 mm and 1 mm short of the finish line are recommended for anterior metal ceramic restoration having adequate fracture resistance, Naina et al., (2011).

The quality of marginal fit not only plays an important role in the prevention of secondary caries but also influences the reaction of the surrounding periodontium. In a study of the marginal fit of various ceramic margins, Hung et al. (1990) concluded that the practical range for clinical acceptability of fit appeared to be in the 50 to 75 µm range. Study carried out by West et al. (1985) also confirmed that porcelain labial margin openings less than 50 µm were consistently achievable.

Another study also evaluated shoulder porcelain (Vident) and concluded that 33 µm marginal opening was also within clinically accepted limits, Omar (1987) and Arnold & Aquilino, (1988) obtained similar results 38 µm marginal opening with their evaluation by using shoulder porcelain (Vident).

A study were carried out by Toogood and Archibald (1978) in order to compare between different techniques for making shoulder porcelain they concluded that in order To overcome the many shortcomings of both the platinum foil and refractory die techniques and to simplify the procedure of porcelain margin fabrication, a direct-lift technique was recommended. With this method dental porcelain is condensed directly on the lubricated shoulder of the master die. The crown is then removed from the die and the restoration is fired without the benefit of a supporting matrix. Manufacturers developed special porcelains specifically for the shoulder-margin area. One major advantage of these high-fusing shoulder porcelains is that they are more stable during firing than conventional body porcelains and thus maintain their marginal configuration, Claus (1984).

Metal-ceramic systems have been reported to offer marginal gaps narrower than 75 mm. Good results in this respect were obtained with gold casting or electroforming techniques, Petteno (2000) However, the marginal fit of metal-ceramic restorations is sensitive to high temperatures and therefore can be affected by the firing procedures involved in their fabrication, Gemalmaz D, Alkumru (1995); Petteno (2000). The current

spectrum of all-ceramic systems, by contrast, has been reported to offer gap widths all the way from47 to 161 mm, Arnold and Aquilino, (1988).

All-ceramic restorations are recommended as an alternative to conventional metal-ceramic restorations, Yeo et al., (2003). Excellent esthetics and superior biocompatibility making them the best restoration for anterior teeth. However, the clinical procedure of adhesive luting is still a sensitive technique, Burke and Trends (2005). The development of ceramic system of improved strength and esthetics has broadened the use of metal-free restorations for anterior and posterior regions However, the longevity of fixed prosthodontics depends on the quality of the marginal adaptation to the abutment teeth. Marginal gaps can create a favorable condition for biofilm deposition, thereby contributing to the development of caries and periodontal disease, Trajtenberg et al., (2005).

All-ceramic crown systems may be fabricated using different techniques. One of these techniques is the heat-press, which is similar to the method of metal-ceramic crowns, as that also utilizes the lost wax method, Gorman et al., (2000). The system produces a high-strength core, consisting primarily of lithium-disilicate glass, Preston (1977). Another technique is the computer-aided design and manufacturing (CAD/CAM) system, which focuses on precise and consistent manufacturing of ZrO2 ceramics with high strength and toughness, Lee et al., (2008).

Essential requirements for the clinical success of all-ceramic crown restorations include good esthetics, high fracture resistance, and perfect marginal fit, Boening et al., (2000). Any marginal integrity that is less than ideal will favour plaque accumulation, thus promoting the development of periodontal disease. Restorations delivered by conventional cementation should have a marginal gap not wider than 75 μm, Jacobs and Windeler (1991). Cement lines bridging wider gaps will dissolve more easily, thus carrying an increased risk of secondary caries.

Microleakage is classically defined as the diffusion of substances, such as bacteria, oral fluids, molecules and/or ions, into a fluid-filled gap or a structural defect that is naturally present or that occurs between restorative materials and tooth structure. The amount of microleakage depends on a number of factors. Complex interactions between variables related to dental restoration, luting agents and tooth structures are known to influence the amount of microleakage, Rossetti et al., (2008).

Marginal deficiencies accelerate plaque accumulation and susceptibility to recurrent caries. Therefore, achieving a gap width below 100 μm is desirable. Adequate internal fit and marginal adaptations are important criteria to consider when evaluating the fit of all-ceramic restorations, Quintas et al, (2004).

All-ceramic crowns have been extensively used in prosthodontics in recent years for their superior gingival response and esthetic quality, while achieving similar marginal accuracies when compared to traditional metal-based restorations, Yeo et al., (2003).

IPS Empress, a leucite reinforced glass ceramic, and IPS Empress 2, a lithium disilicate ceramic, provided better marginal fit, decreased porosity and good mechanical properties compared to traditional particle filled glasses and feldspathic all-ceramic restorations, Guazzato et al., (2002).

The clinically acceptable limit of marginal gaps was reported between 100 and 120 μm, Cho et al., (2002). It was found that system milling densely sintered zirconia demonstrated marginal values of 60 μm and 74 μm, Tinschest et al., (2001). Clinical studies have shown a mean marginal gap of 64 μm for fixed dental prosthesis made by the Lava system which mills semi-sintered Zirconia, Reich et al., (2005).

In vitro study was carried out to compare marginal fit of three all-ceramic crown systems (In-Ceram, Procera, and IPS Empress). results showed that, all crown systems were significantly different from each other at P = 0.05. In-Ceram exhibited the greatest marginal discrepancy (161 microns), followed by Procera (83 microns), and IPS Empress (63 microns), Sulaiman et al., (1997).

2. Material and Methods:

The study was carried out to compare the marginal fit of metal ceramic crowns with porcelain collar and the that of all ceramic restoration.

2.1. Materials:

2.1.1. Ceramic crowns:

Nickel-Chromium alloy (Wiron Light) as a metal coping for feldspathic porcelain (Vita).

for all ceramic crowns 2 system have been selected for the study, IPS Empress (heat pressed Leucite) and IPS Empress CAD (Leucite reinforced ceramic).

2.1.2. Samples:

Thirty samples were prepared for this study. Divided into 3 groups (N=10 in each):

Group A: metal ceramic with porcelain collar

Group B: IPS Empress

Group C: IPS Empress CAD

2.1.3. Die fabrication

A standardized 2 Stainless Steel dies were machined. The first die for all ceramic samples have the following measurements: 6mm height, 8mm gingival diameter, 6 degree taper and 1. 5mm shoulder with 90º cavosurface angle. The metal ceramic samples have the same above measurements except for the finish line which becomes, 1. 5mm shoulder on the facial surface

with 90-degree cavosurface angle, the shoulder on the facial surface was carried to the mid-proximal region both mesially and distally and was blended to a chamfer finish line on lingual surface.
The Stainless Steel master dies were duplicated with polyether impression material (Impregum-Penta, 3 M, ESPE, USA) using custom made trays and these were poured with type IV improved stone (Bella Vest SH, Bego, Germany).

2.2. Methods:

2.2.1. Fabrication techniques for metal ceramic crown with labial collar porcelain (*Group A*)

Lubricant (Waxit, Pegu Dent, Densply, Germany) was applied to the 10 metal ceramic dies with a clean brush. Wax patterns were made by soft inlay wax over the stone dies. The wax patterns were sprued and invested in, phosphate bonded investment material (Bella Vest SH, Bego, Germany). Burnout of the wax patterns were carried out, then the specimens were cast using induction casting machine (Fornex, Bego, Germany)following the manufacturer instructions. The castings were retrieved, sand blasted, all sprues were removed with thin carborundum disk.
The metal copings obtained (Fig 1) were finished and trimmed on the labial aspect with definite distances from the cavosurface margin (1.5mm coronal to cavosurface angle) (Fig 2).

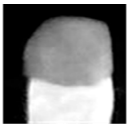

Fig 1: Metal coping

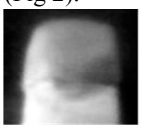

Fig 2– shortened by 1.5mm

The above stated measurements were done using digitalVernier caliper. On lingual surface, the metal coping ends at the cavosurface margin. Veneered surfaces of the coping were finished with abrasive wheel to obtain uniform thickness of 0.3 mm, and the castings were cleaned with a 50 μm aluminum oxide air abrasive. Porcelain build up was done using the direct lift off technique. The porcelain build up was initiated with two applications of opaque porcelain and fired consequently. Shoulder (marginal) porcelain (Vita, VMK95) was applied to the castings with porcelain facial margins, by using the direct lift off technique. Shoulder porcelain (Vita, VMK95 margin) was brushed to the gingival margins. Then, it was carved with a concavity designed to eliminate the over contouring of the final restoration. This layer was dried and fired. A second corrective layer of shoulder porcelain was applied and fired. Then, dentinal porcelain was applied over the opaque and shoulder porcelain for the crowns with porcelain facial margins. Dentinal porcelain was also applied over the opaque porcelain for the crowns with metal collar margins and was fired. Incisal porcelain was applied in layers and was fired (Fig 3). The fit of the crowns was assessed on the respective die visually and tactually with a dental explorer. The fitting surface of the crowns was checked and any interferences should be eliminated with a small round carbide bur.

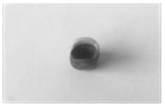

Fig 3– Porcelain shoulder

The crowns were contoured with the abrasive wheels. Measurements were made with a digital Vernier caliper to ensure that the total thickness of porcelain and metal was uniform of 1. 5 mm. Then, the porcelain was glazed.

2.2.2. Fabrication techniques for IPS Empress crowns (*Group B*)

Lubricant (Waxit, Pegu Dent, Densply, Germany) was applied to the 10 dies with a clean brush. Wax patterns were made by soft inlay wax over the stone dies. The wax patterns were sprued and invested in, phosphate bonded investment material (Bella Vest SH, Bego, Germany). Burnout of the wax patterns were carried out, insert a ceramic ingot IPS Empress (Ivoclar Vivadent AG) and alumina plunger in the sprue and placed in the special pressing furnace. After heating to 1165ºC, the softened ceramic is slowly pressed into the mold under vacuum. After pressing, recover the restoration by airborne particle abrasion, remove the sprue, and refit it to the die

2.2.3. Fabrication techniques for IPS Empress CAD (*Group C*)

Cerec inlab CAD/CAM system (Sirona, Bensheim, Germany). In order to acquire the optical impression with the ceric-3 infra-red camera, every die was covered with a high contrast media which was a set of ceric liquid and ceric powder. After designing the samples, the material that will be used for milling the samples can be chosen from the dialogue box (IPS Empress CAD). Finally, the machining icon was selected and the appropriate ceramic block IPS Empress CAD (Ivoclar Vivadent AG), of size C 14, and shade A2 was placed in the milling chamber of the MC XL milling machine. Step bur 12 S (Sirona #62 08 677) was mounted on the left motor and cylinder pointed Bur (Sirona #59 45 535) was mounted on the right motor. Clicking OK on the screen starts the machining. After the milling process completed, the samples were separated with a diamond cutting instrument from the rest of the block and excess material was removed. Samples were covered with IPS Empress Universal Glaze and fired in a programat CS Furnace to 770ºC.

Each casting was seated on its respective stone die and secured with a spring-loaded calliper exerting uniform for all samples during microscopic measurements. the vertical distance of restoration margins to die's finishing line was measured and recorded in three points of on the buccal surface (central, mesio-buccal and disto-buccal) using a stereo-microscope with detection of one micron. The average of every three reading in each point was obtained then the average and standard deviation of the marginal fit in each group was calculated. Statistical differences between the various systems were determined by parametric one-way ANOVA. Results were considered statistically significant at p_0.05.

3. Results

Table 1 gives an overview of the mean marginal gaps and SD measured in each of the three groups. The IPS Empress CAD group of crowns (milled in a Cerec 2 system) revealed the poorest marginal integrity 99. 4±0.53 µm. IPS Empress was next in line with 72. 8±0.71 µm. Compared to this groups of all-ceramic restorations, the result of 32. 5±0.75 µm obtained with conventional collarless metal ceramic restorations was clearly better.

The IPS Empress restorations yielded a value of 72. 8±0.71 µm, thus lying about halfway between the metal-ceramic and IPS Empress CAD Groups. Table 2 illustrates which of the various inter group differences reached statistical significance.

It turned out that metal-ceramic collarless was significantly superior to the other two all-ceramic systems. Conversely, IPS Empress CAD yielded significantly lower levels of marginal integrity than the other two Groups metal-ceramic and IPS Empress

Fig. 1: Graphic representation of average values and standard deviations in all groups

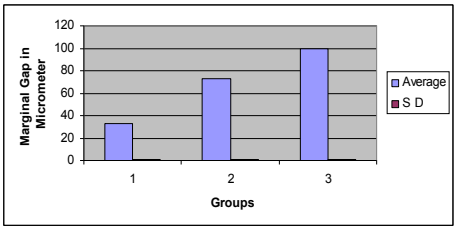

Table 1: Average marginal gap widths measured in the three Groups

	Group1	Group 2	Group 3
Average of marginal gap in the three groups in mµ	32. 6	72. 5	99. 6
	34	72. 9	98. 8
	32. 9	73. 2	100
	32. 2	71. 3	100.3
	31. 7	72. 8	99. 2
	32. 2	73. 1	99. 5
	33. 4	74	99. 3
	31. 3	73. 6	99. 9
	32. 2	72. 3	98. 5
	32. 5	72. 5	99. 1
	32. 5	72. 82	99. 42
Average S D±	0.746994	0.708237	0.526878

Table 2: Distribution of significant inter-group differences in gap width measurements.

	Metal-ceramic collarless	IPS Empress	IPS Empress CAD
Metal-ceramic collarless		*	*
IPS Empress	*		*
IPS Empress CAD	*	*	

Asterisks (*) indicates the presence of statistically significant differences.

4. Discussion

Several techniques have been developed over the years for fabricating metal ceramic crowns with porcelain facial margin. The best known techniques are Platinum foil technique.

Refractory die technique. Direct lift-off technique, and Porcelain wax technique. Out of the various techniques available for fabricating the collarless metal ceramic crowns, direct lift-off technique was proved to be the simplest and easiest, and thus used in this study, Ulusoy and Toksavul (2002); Sikka et al., (2010). The luting agents may influence the marginal discrepancy values by elevating the crown after cementation. To eliminate the effect of this factor on marginal discrepancy the study was carried out without cementation of the restorations.

Marginal discrepancies in the range of 100 µm have been reported to be clinically acceptable with regard to longevity of a restoration, Shiratsuchi et al., (2006). All the copings tested in this study were well within this limit.

The present marginal discrepancy values of metal-ceramic collarless restorations (32. 5 &15. 8 µm) showed similarity to those of previous studies, as that obtained by John Joseph **(** 1991) who found that The mean marginal opening for the platinum foil technique was 17. 7 µm while was 33. 5 µm for the direct-lift technique using high-fusing shoulder porcelain. Also, was near to the results of West et al., (1985). Who reported a mean marginal opening ranging from 13. 5 to 29. 5 µm with the direct-lift technique using conventional body porcelain. Furthermore the results of this study also compare favourably with the conclusion of Donovan and Prince (1985) that marginal gaps of only 16 to 34

micrometers can be consistently achieved using all-porcelain labial margins.

In addition to the good results of marginal adaptation of metal-ceramic collarless restorations it was concluded that the maximum load required to fracture the test specimens even in the groups without the metal collar was found to be exceeding the occlusal forces. Therefore, the metal frameworks with 0.5 mm and 1 mm short of the finish line are recommended for anterior metal ceramic restoration having adequate fracture resistance, Naina et al., (2011).

The results obtained from the all ceramic samples (Groups B, C) were slightly similar to the results of Reich et al., (2000) whom concluded that, The in vitro gap width measurements for both the IPS Empress system and the Cerec 3D method revealed satisfying mean results below 100 µm.

IPS Empress CAD group of crowns (milled in a Cerec 2 system) revealed the poorest marginal integrity 99. 4 µm this result was in agreement with the result obtained by Polansky et al., (2010) whom found that the greatest marginal gap was obtained from Mark II group of crowns (milled in a Cerec 2 system)142. 3 µm. These results may be due to the possible inaccuracies resulting from the scanning process, software design, milling, and shrinkage effects. These inaccuracies could lead to poor restoration fit, Bindl and M¨ormann (2005).

5. Conclusions

Within the limitations of this in vitro study, the conclusion can be drawn that, the marginal precision of fit of crown restorations is significantly better with a porcelain-butt margin than the other two all ceramic crown restorations.

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