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A Comparative Evaluation Of Marginal Fit Between Zirconia And Lithium Disilicate Crowns Fabricated By Cad-Cam, Using Scanning Electron Microscopy - An In Vitro Study.

Dr. Areeba Zainab Kakroo[1], Dr. Shabana Azmin[2], Dr. Pallavi Sirana[3], Dr. Abhi Sharma[4]
(Department Of Prosthodontics And Crown And Bridges, Institute Of Dental Studies And Technologies, India)

Abstract:
Background: *For a dental restoration to be successful, one needs to take several factors into account however, prosthetic precision is largely affected by marginal fit of the restoration as it directly influences the longevity and clinical success of the dental restoration. Reason being, increased marginal discrepancy leading to cement dissolution which in turn leads to accumulation of the tooth biofilm, hypersensitivity, marginal discoloration, microleakage, caries, endodontic and periodontal diseases.*
Material and methods: *Forty intact human mandibular premolars were prepared by means of standardized preparation. The prepared samples were randomly divided into two groups. Each group consisted 20 prepared samples for fabrication of Zirconia and Lithium disilicate crowns respectively using CAD/CAM. Crowns were fabricated and cemented using dual-cure resin cement. Scanning electron microscopy was used to achieve marginal gap values in the sagittal plane at mesial and distal margins of each specimen. The results were statistically analysed using independent t-test.*
Results: *Overall marginal gap was found to be more among lithium disilicate crowns (group II) as compared to Zirconia crowns (group I). the difference in marginal gap between both groups was found to be very highly significant (p value <0.001). However, marginal gap values of both groups fall under clinically acceptable values, nonetheless Zirconia presented the best marginal fit among the experimental groups.*
Conclusion: *The overall mean marginal gap of Zirconia crowns (28.97µm) was found to be lesser than that of Lithium disilicate crowns (67.23µm) and the recorded marginal gap values fall under clinically acceptable values for both the groups.*
Key-words*: All ceramic restorations, marginal fit, lithium disilicate, zirconia, CAD/CAM, Scanning electron microscope.*

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I. Introduction

Dentistry today, is not restricted to mere treatment of dental ailments, but consists of a much larger picture which also includes aesthetics.

Earlier, the dentist was mainly concerned with the restoration of functionality rather than the appearance of the restoration. With the advent of metal-ceramic crowns in 1960s, the whole scenario of dentistry changed for better. With the life-like appearance of the ceramics along with the strength of metal, metal-ceramics gained popularity and became dentist's choicest restoration in no time.

As people are getting more and more conscious about their appearance, the patient's demands are more aesthetically driven and the acceptable appearance of the teeth is one of the patient's primary requirements. Therefore, to meet the demands of patients, the attention of scientific research is progressively focusing on aesthetically sound materials, in particular, zirconia and lithium disilicate, in order to gain knowledge about the properties, indications and limitations of these materials. [1]

Zirconia is one of the most promising contemporary restorative materials, as it yields very favorable mechanical properties and a reasonable aesthetics. Zirconium dioxide (ZrO_2), known as zirconia, is a white crystalline oxide of zirconium. Enhanced fracture toughness can be achieved in zirconia by controlled stress-activated conversion of tetragonal crystal to larger monoclinic crystals which will resist the crack propagation and hence strengthen it, process known as 'transformation toughness'. The biocompatibility of zirconia has been well documented and in vitro and in vivo tests on Y-TZP have revealed good biocompatibility with no adverse reactions with cells or tissues.

Zirconia has been used as a structural material for dental bridges, crowns, inserts, and implants, mostly because of its bio compatibility, high fracture toughness and radiopacity.

Ivoclar Vivadent (Amherst, N.Y.) introduced a lithium disilicate glass ceramic material for use in all-ceramic restorations. It is available as an ingot that can be press-fit (IPS e.max Press, Ivoclar Vivadent) and as a block that can be milled with computer-aided design/computer-aided manufacturing (CAD/CAM) technology (IPS e.max CAD, Ivoclar Vivadent). [2]

Lithium disilicate is a highly aesthetic, high strength material and is ideally suitable for fabrication of monolithic restorations or veneered restorations in anterior and posterior region. It has versatile applications and extensive indications ranging from veneers to three unit bridges. The outstanding performance of the material in the dental field is based on a combination of excellent flexure strength(~ 350 MPa) and high fracture toughness, apart from its appealing aesthetics.

However, for a restoration to be successful, the parameter of utmost importance is the marginal fit of the crown. Due to the increased marginal discrepancy, the cement makes up a thicker layer which is more influenced by the oral cavity environment, resulting in cement dissolution which in its turn leads to accumulation of the tooth biofilm, hypersensitivity, marginal discoloration, microleakage, caries, more gingival sulcular fluid flow, pulp infection and eventual bone loss and lesion of periodontium. Besides, thick cement layer favors a higher stress concentration that can lead to microcracks and even to marginal fractures of loose ceramic. A superior marginal fit markedly reduces the cement dissolution and microleakage thereby decreasing the recurrence of dental caries and development of periodontal diseases and extends the longevity of the restoration.

Marginal fit of fixed dental prostheses is determined by the size of the gap between the margin of the restoration and finish line of the prepared tooth. The most important factors influencing marginal and internal fit of fixed dental prostheses are the material used, mold technique, the type of cement, dentist's skills, the type of finish line as well as peculiarities of various technique of restoration fabrication.

Marginal fit is clinically evaluated by probing. Marginal fit can be indirectly assessed radiographically, and through epoxy resin replicas by light and scanning electron microscopy. Generally adopted approach to the acceptable value of marginal fit still hasn't been suggested. Some specialists consider the value lower or equal to 120μm [3] to be acceptable, while others believe it should be less than 100μm [3] and there are still those who argue, that the acceptable value should range between 20-75μm.[4-6]

Moreover, over the past few decades, CAD-CAM has allowed dentists to look beyond the traditional techniques and deliver to the patient to the best of their abilities. Materials like lithium disilicate and zirconia has made it possible for the dentist to apply the digital workflow for the preparation of single crowns as well as multiple unit FPDs. There is an opinion, that restoration precision has significantly improved since CAD/CAM systems were introduced in dentistry. CAD-CAM has proven to be the best so far in terms of accuracy and time efficiency.

Therefore, this study was taken to make a comparative evaluation of marginal fit between lithium disilicate and zirconia single crowns produced with CAD-CAM, in order to conclude the difference between the marginal fit of different materials used, and if the marginal discrepancy of respective material falls under clinically accepted values.

Material And Methods

Forty human intact mandibular premolars were selected for the study. Dental plaque, calculus and periodontal tissues were carefully removed. The teeth were stored in the preserving media (normal saline).

Study Design: Prospective observational study

Study Location: This was an in-vitro study done in Department of Prosthodontic and Crown and Bridges, at institute of dental studies and technologies, Modinagar, Ghaziabad, Uttar Pradesh.

Study Duration: November 2019 to November 2021.

Sample size: Forty samples

Tooth preparation and sampling procedure:

Tooth preparations were carried out by a single operator for single crown restorations using flat-end and round-end tapered burs (Shofu, Japan) consecutively with calibrated diameters. High speed water spraying type airotor was used in order to prevent the teeth from being desiccated due to high heat and pressure. Preparation depths were kept under check using silicone indexes that were obtained before tooth preparation. The preparations were standardized as follows:

Margin design: 1 mm circumferential rounded shoulder, with rounded internal angles;

axial reduction: 1.5 mm;

occlusal reduction: 1.5-2 mm (anatomically shaped);
total occlusal convergence angle: 12°.

The cervical margins were placed in enamel and followed the cemento-enamel junction; then they were polished with fine and extrafine diamond burs. The preparations were finally checked by means of a digital caliper with a precision of 0.01 mm.

The roots of each specimen were trimmed off in order to fit them in the typodont jaw set so that it can be scanned using an intra-oral scanner, since the intra oral scanner requires the scan of the opposing arch and the bite scan.

The specimens were randomly distributed into 2 groups (n=20) (fig1,fig2) as follows, according to the type of crown they would subsequently receive:
Group I: CAD-CAM zirconia single crowns (Aidite, Superfect Zirconia block, Qinghuangdao, China);
Group II: CAD-CAM Lithium disilicate single crowns (Aidite, Cameo Glass Ceramic blocks, Qinghuangdao, China).

Fig 1. 20 teeth prepared for fabrication of Zirconia crowns

Fig 2.20 teeth prepared teeth for fabrication of Lithium disilicate crowns

Scanning of Prepared Samples

Once the teeth were prepared, 3Shape TRIOS intra oral scanner was used for scanning of all prepared samples. Firstly, the prepared tooth was mounted on the typodont jaw set at the place of 35 and it was scanned (fig.3), followed by the scan of maxillary typodont jaw set (fig. 4) and finally the scan of the bite (fig. 5) was done. These scans were then transferred to the CAD software after converting into STL format.

Fig 3, Scanning of the prepared tooth

Fig 4, Scanning of opposing arch

Fig 5, Scanning of bite

Computer-Aided Designing and Computer-Aided Manufacturing

Once the scanning of the samples was complete and the 3D images were obtained, these images were then converted into STL format and the data was sent to the CAD software for designing of zirconia and lithium disilicate crowns for group 1 and 2 respectively. The crown design and finish line marking were planned (fig.6). The CAD-CAM parameters were as follows: virtual die spacer: 0.40 mm, occlusal milling offset: −175 mm, proximal contact strength: 25 mm, occlusal contact strength: −50 mm, radial minimal thickness: 500 mm, occlusal minimal thickness: 1000 mm, and marginal thickness: 50 mm.

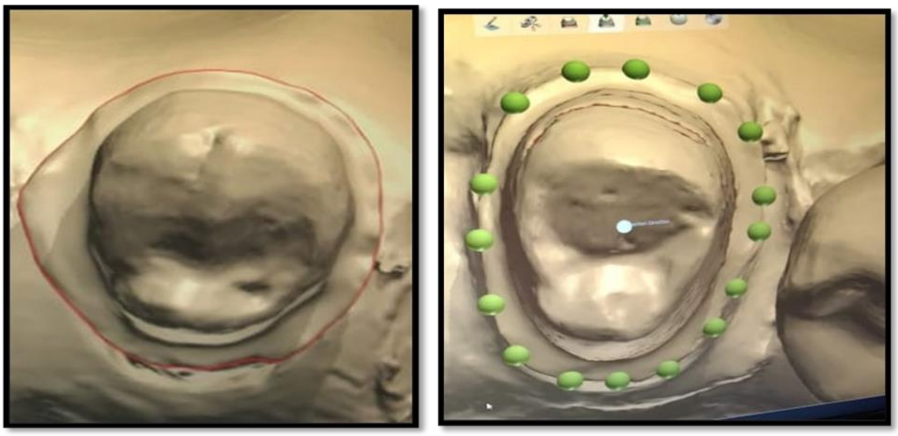


Fig 6, Finish line markings were planned.

We used 3 Shape CAD software for designing of both Zirconia and Lithum disilicate crowns. The software contained various tools like undercut reduction, surface smoothening, addition or reduction of material, reducing or increasing the height of the crown, changing the inclination of the crown etc which helped us to optimally design each crown for both the groups (fig. 7).

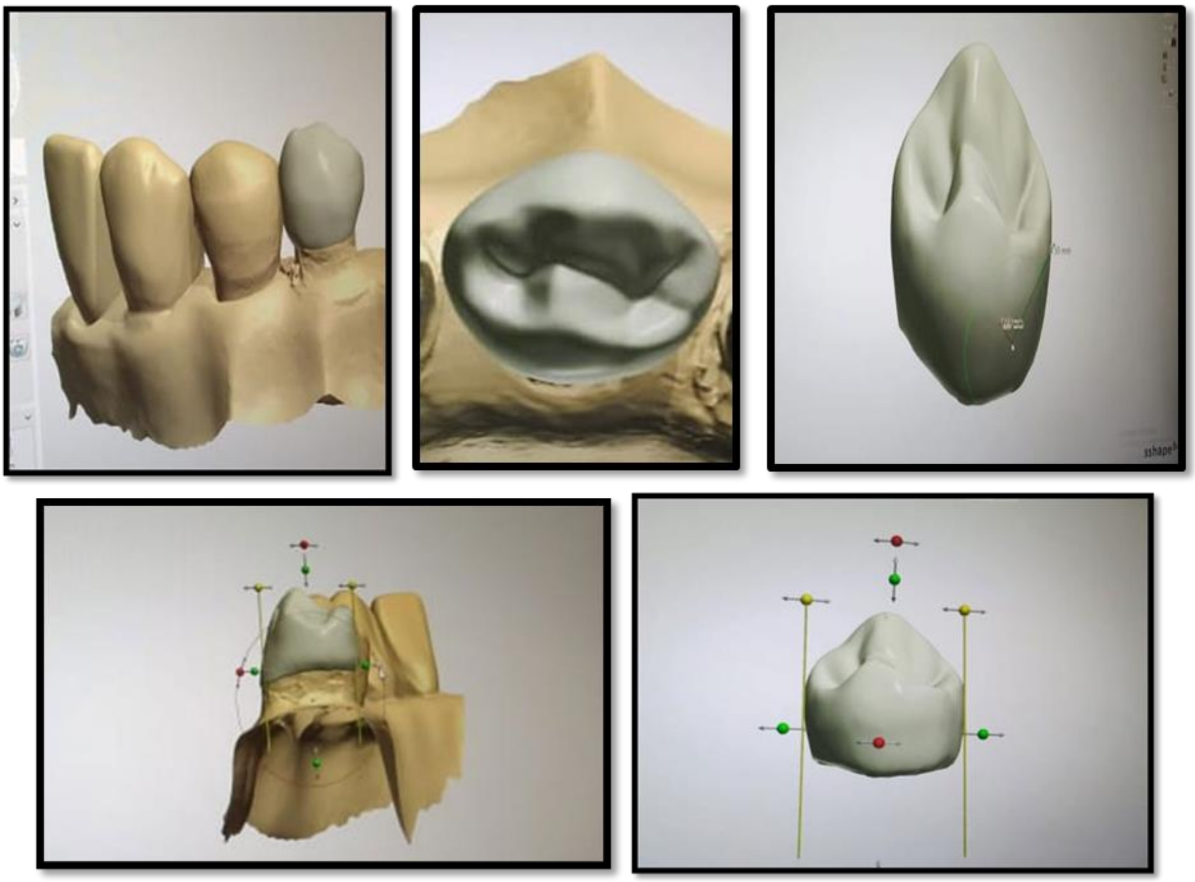


Fig 7, Final crown design.

The data sets from the CAD software were converted into milling sequence using CAM software (VHF, Germany) and finally loaded into the milling device to mill a part out of the stock material i.e., Zirconia blanks for Group I and Lithium Disilicate blocks for Group II.
We employed subtractive manufacturing for fabrication of both zirconia and lithium disilicate crowns.

Group I - Zirconia Crowns:

20 mandibular premolar crowns were milled out of a single block (Aidite, Superfect zirconia block) (fig. 8) using the Vhf milling machine which is a 5-axis milling machine. The zirconia blank was fitted in the milling machine and the crowns were dry-milled and carefully trimmed out from the block (fig. 9).

Careful handling of the pre-sintered zirconia crowns is very necessary due to the brittle nature of the material. Sprues were trimmed and residual zirconia powder was removed with the help of sable hair brush (fig. 10). Once the crowns were clean, a layer of desired shade (A2) was applied on the outer surface of all the crowns by dipping them in the staining liquid (Aidite, Qinghuangdao, China). They were kept on the tissue paper for absorbing excess stain.

The dried crowns were now placed over ceramic beads (fig. 11), ready for the sintering process. The program was set in the sintering machine (TABEO-1/M/ZIRKON-100,USA) and was sintered at 1500°C for 12 hours (overnight). Lastly, glazing liquid (Ivoclar Vivadent, USA) was applied on the crowns and glazing was done in the glazing unit as per the pre-set program in the machine. The glazing of zirconia was done at an initial temperature of 500° C for 4 minutes, gradually reaching the highest temperature of 940° C and finally maintaining the temperature at 600°C for 1 minute. Total of 20 crowns were fabricated from zirconia blank (fig. 12 and fig. 13).

Fig 8, Zirconia blank **Fig 9, Milling completed**

Fig 10, Sprues trimmed **Fig 11, Milled crowns placed on ceramic beads**

Fig 12, Zirconia crown finished

Fig 13, (20) Zirconia crowns completed

Group II- Consisted Of 20 Lithium Disilicate Crowns:

20 lithium disilicate crowns were milled from 20 separate blocks (fig, 14) (Aidite, Cameo Glass Ceramic blocks, Qinghuangdao, China) using the milling machine (VHF S1, Germany). The blocks were fitted in the milling machine and crowns were wet-milled (fig. 15) and carefully trimmed out from the blocks. The calcination curve included heating at the initial temperature of 450^0 C, drying time of 4 mins, reaching the highest temperature of 840^0 C, and finally maintaining it at the final temperature of 300 ^{o}C for 1 minute (fig, 15). The crystallisation process was completed within 20 minutes, and the crowns acquired the desired shade of dental prosthesis. (fig 16). The crowns were then placed in glazing unit (fig. 17) and the temperature for glazing was set in the machine. The glazing of lithium disilicate was done at an initial temperature of 500^o C for 2 minutes, gradually reaching the highest temperature of 820 ^{o}C and finally maintaining the temperature at 300^{o}C for 1 minute. Total of 20 crowns were fabricated from lithium disilicate blocks (fig 18, fig 19).

Fig 14, Lithium disilicate blocks

Fig 15, Milling completed

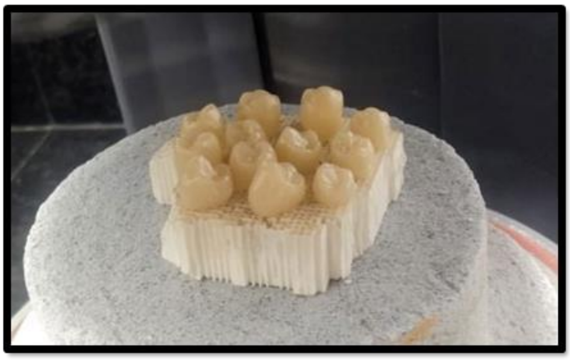


Fig 16, Crown kept for calcination **Fig 17, Glazing completed**

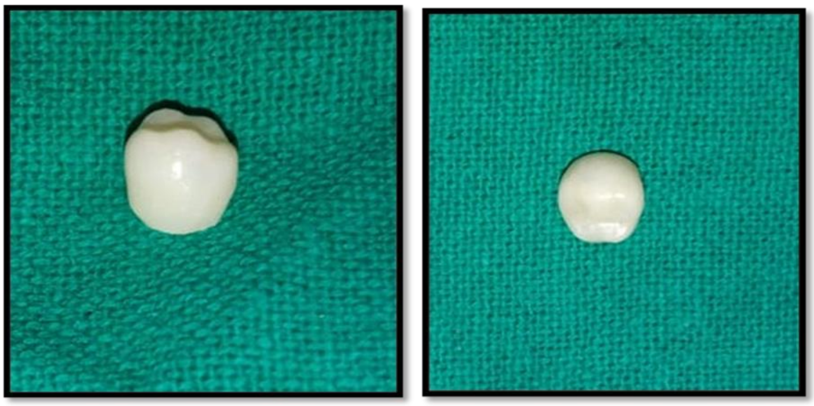


Fig 18, Lithium disilicate crowns finished

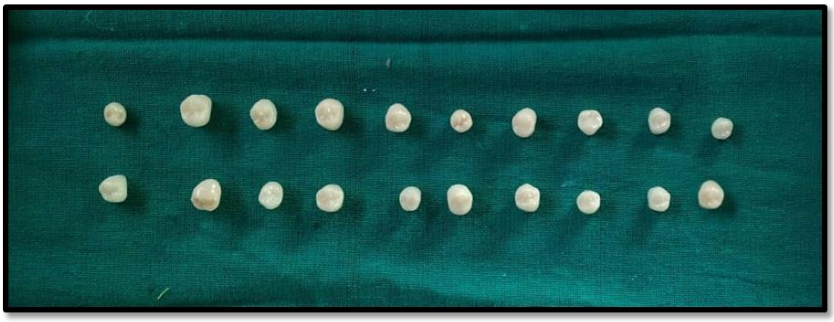


Fig 19, (20) Lithium disilicate crowns completed

Cementation of the Crowns

After the fabrication of crowns, they were luted using FUSION ULTRA D/C (Prevest DenPro) (fig. 20) which is a low viscosity, light and chemically cured, radiopaque, two component nano-hybrid luting cement was used to lute the crowns of both the groups. The prepared sample teeth were properly rinsed and dried and bonding agent was applied. The material was dispensed on the inner surface of the restorations from the auto-mix tip. The fabricated crowns were now placed over the prepared sample teeth, finger pressure was applied for 3 minutes and excess cement was removed with the help of an explorer. After the initial setting time of 2 minutes, the cement was light cured for 20-40 seconds and all specimens were stored in a laboratory oven at 37°C and 100% relative humidity for 24 hours. (fig. 21).

Fig 20, Dual cure resin cement

Fig 21, Cementation of the crown

Sectioning of the Samples

Thereafter all the luted samples were mounted in the metal holder (fig. 22) and sectioned using an Abrasive Cutting Machine by placing the mounted samples inside the machine (fig. 23). The samples were sectioned precisely into two equal halves in the bucco-lingual direction (fig. 24), using a metal cutting disc of 0.5 mm diameter.

Fig 22, Samples prepared for sectioning

Fig 23, Sample placed inside the sectioning machine

Fig 24, Sectioned buccolingually sample

Marginal Fit Analysis Using SEM

Scanning electron microscopy was done with **ZIESS ULTRA PLUS** scanning electron microscope (Fig 25) at 20.00 KV and 2.45 mbar pressure after 20nm gold particle coating through Desk Sputter and Carbon Coater (DSCR) machine (VacCoat, UK).

The sectioned samples were mounted on stubs to be fixed for the sample to be sputter coated by gold particles in 8 cycles in presence of argon gas for 300 seconds at 50 Ma current (fig 26, fig 27). Then the samples were studied under scanning electron microscope. The images obtained were utilised for measuring the specific sites at mesial and distal margin in each specimen (fig 28, 29,30 and 31). After acquiring the scans of the samples on the SEM monitor, the software was used to measure the marginal gaps using the micrometer scale, by dragging the cursor from the crown margin till the preparation margin at 2 points on cervical finish line. The measurements thus depicted on the screen were noted down for both the points of each sample and arranged in a tabulated format for both the groups.

Fig 25, Scanning electron microscope

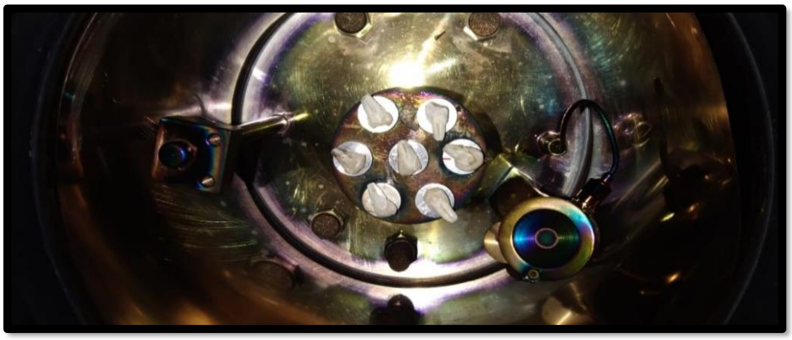


Fig 26, Samples kept inside sputtering machine

Fig 27, Gold coated samples placed on stubs

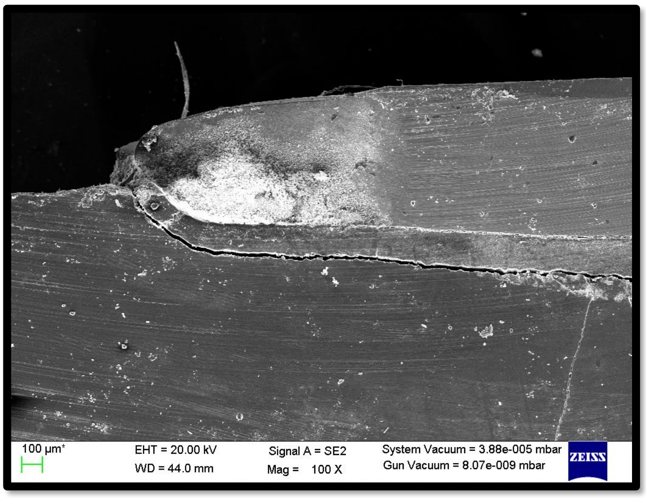


Fig 28, SEM image acquired for group I sample

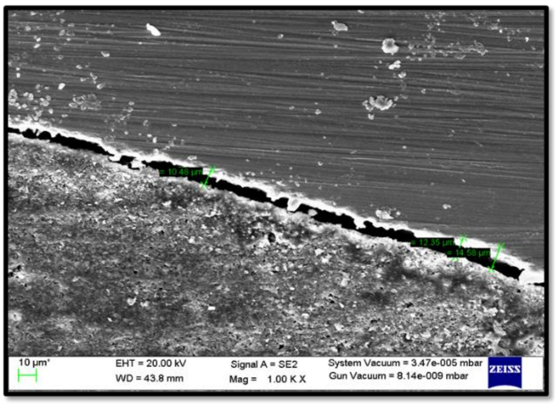


Fig 29, Marginal fit measured for group I samples

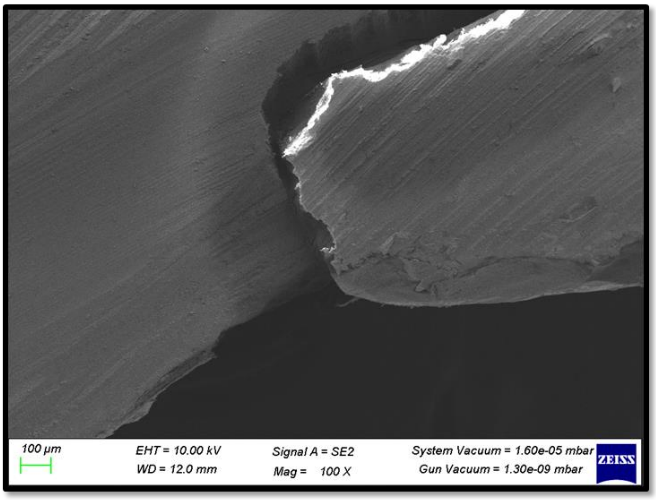


Fig 30, SEM image acquired for group II samples

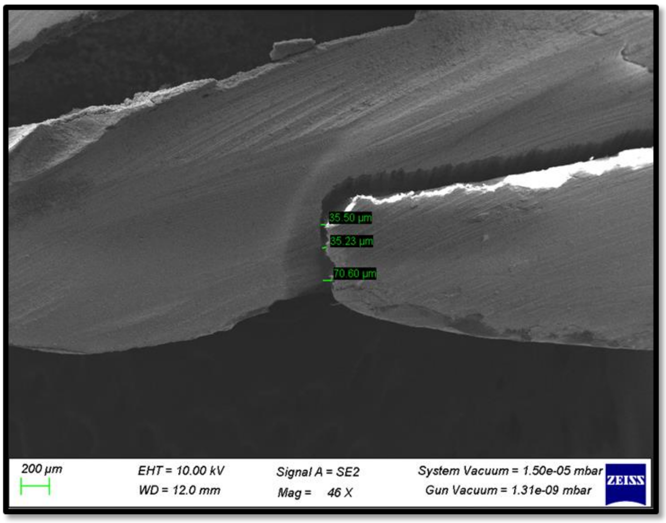


Fig 31, Marginal fit measured for group II sample

Statistical Analysis

The statistical software namely SPSS 19.0 (SPSS Inc., Chicago,IL, USA) was used for analysing the data and Microsoft excel was used to generate graphs, tables, etc.

The data obtained was compiled systematically, transformed from a pre-coded proforma to a computer and a master table was prepared. The total data was distributed meaningfully and presented as individual tables along with graphs. Inferential statistical analysis was carried out in the present study. Results on continuous measurements were presented on Mean ± SD (Min-Max). Significance was assessed at 5% level of significance. Independent't' test was used to find the significance of study parameters on ordinal scale between two groups.

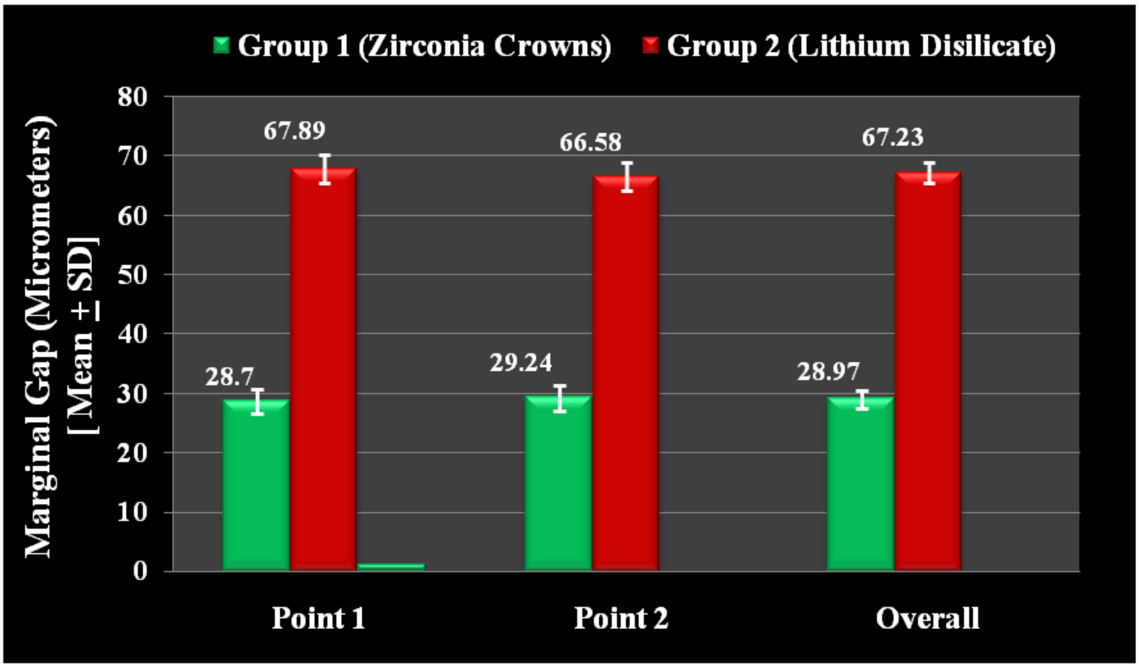
II. Results

Mean values and Standard Deviations (SD) recorded at all measuring points in each group are recorded in Table 1.

TABLE 1 : Mean values and SD of marginal fit (in µm) at all measuring points:

Marginal Gap (micrometers)	Group 1 (Zirconia Crowns)		Group 2 (Lithium Disilicate)		Independent 't' Test	p - Value
	Mean	**SD**	**Mean**	**SD**		
Point 1	28.70	1.98	67.89	2.33	57.353	**< 0.001***
Point 2	29.24	2.15	66.58	2.41	51.678	**< 0.001***
Overall	28.97	1.59	67.23	1.77	72.004	**< 0.001***

SD – Standard Deviation, * – Very Highly Significant



Graph 1: Mean Marginal Gap at two points among both groups

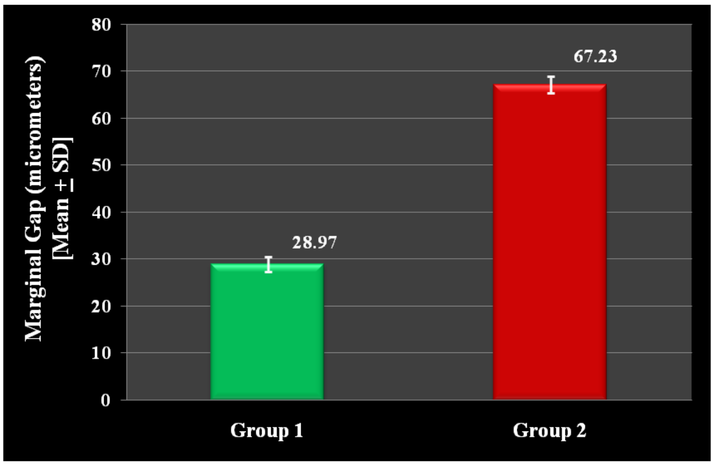
Descriptive statistics of absolute marginal gap measurements relative to crown type are shown in Table 2, along with Standard Deviations.

TABLE 2: Absolute marginal gap values and sd among experimental groups:

	Marginal Gap (micrometers)	
	Mean	**SD**
Group 1 (Zirconia Crowns)	28.97	1.59
Group 2 (Lithium Disilicate)	67.23	1.77
Independent 't' test	72.004	
p-Value	**< 0.001 (VHS)**	

SD – Standard Deviation, VHS – Very Highly Significant

Marginal Gap was found to be more in group 2 compared to group 1 and difference in marginal gap between groups was found to be very highly significant (p- value <0.001).



Graph 2: Absolute Marginal Gap between group I and II

- The mean marginal gap of zirconia crowns was better than lithium disilicate crowns.
- The mean marginal gap for both the groups fell under the clinically acceptable values.

On the basis of the results of the present study the null hypothesis was rejected since the Lithium disilicate crowns showed significantly higher marginal gap values as compared to Zirconia crowns.

III. Discussion

The exponential growth in the applications of digital dentistry offers unprecedented and exciting opportunities to improve dental care. Indeed, the use of computer-aided design and computer-aided manufacture (CAD/CAM) in prosthodontics, through directly acquiring intra-oral digital impressions, and fabricating single crowns, fixed partial dentures (FPDs) and removable partial/complete dentures has become routine practice for many dentists worldwide.

The advantages of using CAD/CAM technology to fabricate crowns are: decreased chair time, elimination of a second delivery appointment, elimination of provisionalization, elimination of errors caused by dimensional changes of materials and impression techniques, and improved communication between the clinician and the laboratory. [45] Accuracy of fit of CAD/CAM ceramic crowns is a principle concern. A wide range of variables including the scanning process, software design, milling, and shrinkage following final firing of the restoration can affect the marginal accuracy of these restorations. Based on information from the dental model that has been entered, processes, including blocking out of undercuts and manual entry of incomplete margins and air bubbles, are conducted within the design software, and errors can arise during these steps.[3]

Lithium disilicate glass-ceramic material was introduced by Ivoclar Vivadent (Amherst, NY) for fabrication of anterior and posterior crowns, inlays, onlays, and veneers. There are two types of material available, an ingot that can be press-fit (IPS e.max Press; Ivoclar Vivadent) or as a block that can be milled using CAD/CAM technology (IPS e.max CAD; Ivoclar Vivadent).[7] Lithium disilicate ceramics undergo a two- stage crystallization process during the generation of all-ceramic crowns. Lithium metasilicate crystals are precipitated during the first stage. This creates a blue-voilet color in the block during milling, thus accounting for the commonly used "blue-block" description. This pre-crystallised state allows the block to be milled easily without excessive diamond wear or damage to the material. The final crystallisation occurs after the crown has been milled to the desired form at maximum temperature of 840 ºC in vacuum. The metasilicate crystals are thus dissolved completely and lithium disilicate crystallises. This process also converts the blue shade of the pre-crystallised block to the selected tooth shade and the crystal size now increases from 0.5 micrometer to approximately 5 micrometers.[2] It is hypothesized that the observed increase in marginal gap after crystallization firing of lithium disilicate crowns is due to shrinkage accompanying the densification of the ceramic material during the additional heating stage, which manifested as an enhanced opening at the marginal area.[9] However, based on the results reported by Wiedhahn,[79] the effects of the crystallization process can be verified by checking the marginal, proximal, and occlusal fit after the milling procedures. Shrinkage of approximately 0.2–0.3% encountered during the crystallization process does not affect the fit of single crowns. Further, another study reported that the post-sintering shrinkage of glass-ceramic composite material does not greatly affect the maintenance of "good fit," because the material is extremely fine.[20]

Zirconia has been used as a structural material for dental bridges, crowns, inserts, and implants, mostly because of its bio compatibility, high fracture toughness and radiopacity. Currently, three types of zirconia blanks are available for the CAD/CAM system. One is the completely sintered dense blanks for direct machining by CAD/CAM. The other two types of blanks for CAD/ CAM fabrication require post-machining sintering to obtain final products with sufficient strength. Completely sintered blanks are advantageous for avoiding undesirable dimensional changes — a result of sintering shrinkage that occurs during post-machining heat treatments; however, they have the disadvantage of damaging tools and causing chip formation during machining. On the other hand, raw-stage blanks are advantageous for easy machining without damaging tools and causing chip formation.[28] The sintering is done at 1500 ºC for 12 hours. These dimentional changes that occur during post-machining sintering causes increase in the marginal gap and hence decreased marginal accuracy or fit.However, for a restoration to be successful, the parameter of utmost importance is the marginal fit of the crown.

Holmes et al introduced a classification for marginal gap in 1989.[7] According to their classification "the perpendicular measurement from the internal surface of the casting to the axial wall of the preparation is called the internal gap and the same measurement at the margin is called the marginal gap." [7] Different values for marginal fit have been reported throughout the literature. They range from 7.5 to 206.3 μm. [8,] **McLean and Von Fraunhofer** proposed a marginal gap and cement thickness of less than 120μm for successful restorations after evaluating more than 1000 crowns following 5 years of service. There is no clinical or evidence-based consensus regarding whether a specific marginal gap may be clinically acceptable for a given patient. Some authors showed that a marginal fit ≤100 microns is more suitable.[2,8] Others consider a fit ≤75 microns clinically acceptable.[83] However, in additional studies, a marginal fit of between 25 and 40 microns for cemented restorations was considered to be a clinical goal [4], but additional studies have shown that these levels are difficult to be achieved.

The marginal gap of zirconia single crowns was reported to range between 36.56 μm and 70.94 μm. [3,5] whereas the precision of fit of lithium disilicate restorations varied between 61.86 μm and 103.75 μm, [3,6] which is in accordance with our results.

The results of our in-vitro investigation were consistent with those achieved in similar previous studies[3,8,9]. All the tested crown configurations showed clinically acceptable values of marginal discrepancy.

Particularly, the CAD-CAM zirconia crowns showed the best precision of fit at the preparation margins. This was probably due to the fact that dental CAD-CAM systems were developed to process polycrystalline materials and, consequently, the dedicated software produce better blanks[19]. Although they are already clinically acceptable, further developments in dental CAD-CAM technologies would probably improve the performances of such systems in the manufacturing of glass-based materials such as LD-based ceramics, since possible errors may be compensated in different processing steps. Another reason for higher marginal gap found in Lithium Disilicate crowns can be due to the post-crystallisation shrinkage. It is hypothesized that the observed increase in marginal gap after crystallization firing of lithium disilicate crowns is due to shrinkage accompanying the densification of the ceramic material during the additional heating stage, which manifested as an enhanced opening at the marginal area.[9]

Although sample sectioning and SEM evaluation, as is done in our research, have been used for years to evaluate the marginal and internal fit of restorations,[26,27,29] it is worth noticing that those approaches are destructive methods that can be performed on a limited number of tooth slices and sectioning inevitably involves the loss of some information; furthermore, the cutting procedures are time-consuming and preclude further use of the specimens.[141] Other techniques to evaluate marginal fit that are present in literature include : direct-view technique with a stereomicroscope,[5,10] or optical microscope,[7] the 3-dimensional laser scanner[12], the cross-sectioning technique[18], the weight technique [29], the impression replica technique[6,19,26] ,and computerized x-ray microtomography.[11,]

There are various studies that have compared and evaluated the marginal fit between conventional and digital techniques.[17,28,] They concluded that the accuracy of crowns fabricated by using digital impressions was at the same level or better as compared to conventional impressions.

Accurate marginal adaptation is considered as one of the most important factors for the clinical success of dental prosthesis. Marginal fit is basically defined as the gap between the margins of teeth and the internal surface of coping. Excessive marginal discrepancy accelerates the rate of cement dissolution and thus, microleakage which may cause hypersensitivity in the vital teeth and secondary caries in vital and non-vital teeth. Furthermore, it increases the plaque retention and changes the composition of sub-gingival microflora leading to periodontal diseases.

The introduction of the new generation of particle-filled and high strength ceramics, hybrid composites and technopolymers in the last decade has offered an extensive palette of dental materials broadening the clinical indications in fixed prosthodontics, in the light of minimally invasive dentistry dictates. Moreover, last years have seen a dramatic increase in the patients' demand for non-metallic materials, sometimes induced by metal-phobia or alleged allergies. Therefore, the attention of scientific research has been progressively focusing on such materials, particularly on lithium disilicate and zirconia, in order to shed light on properties, indications and limitations of the new protagonists of the prosthetic scene.

The present *in vitro* investigation was a preliminary evaluation of the marginal and internal adaptation of different types of all-ceramic crowns. Experimental studies with thermal cycling and cyclic loading stress protocols would be desirable to confirm the results of the present study. Furthermore, although the *in vitro* recorded gaps are in accordance with current clinical parameters, *in vivo* adaptation values could be far higher. Consequently, randomized clinical trials evaluating the tested crown-cement configurations would be necessary to substantiate the clinical outcome in the medium-long term.

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