MARGINAL FIT OF MONOLITHIC ZIRCON CROWNS FABRICATED BY DIFFERENT DIGITAL IMPRESSION TECHNIQUES

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ABSTRACT

Purpose: The aim of this study was to assess the precision fit of different techniques of digital impression for the prepared abutment, its conventional impression, and the stone die by evaluating marginal fit of monolithic zirconium crowns .

Materials and Methods. A standardized Computer Numerical Control machine (CNC) will be used to reduce a standred stainless steel master die with nearly similar dimensions, an occluso-gingival height of 6 mm, a taper of 6° and 1 mm shoulder circumferentially. The overall diameter of the specimen at the base is 8-8.5 mm. Poly vinylesiloxan impression was taken and poured with type IV stone to obtain the stone die .The master die (prepared abutment), the impression and the stone die were digitally scanned for fabrication of monolithic zircon crowns. Three groups of zirconium crowns 10 crowns per each as follow: First group (Gp1) :standard stainless steel master die. Second group (Gp2): Poly vinylesiloxan impression of the master die ;Third group (Gp3): Stone die .The master dies and the impressions were sprayed before scanning while the stone dies were not.The three groups were scanned , the zircon crowns were designed with:Prettau® Zirkonzahn®,sotware and milled from Zirconium block . All the milled crowns seated on the master die . A specially designed device was machined in order to aid in specimen holding during gap evaluation. A digital image analysis system was used to measure and qualitatively evaluate the gap width. Inside the Image J programming, all points of confinement, sizes, outlines and estimated parameters are communicated in pixels. At that point morphometric estimations were improved the situation each shot 4 equidistant milestones along the minimal perimeter for each surface of the example (Mesial, buccal, distal, and lingual). At that point the information acquired were gathered, arranged and afterward subjected to measurable examination.

Results: One way ANOVA test was utilized to look at between the minorgap of the three gatherings. Where P value equal 0.09 , it was viewed as that there is no-huge difference between them. While there is no significance, still the higher negligible gap was recognized in the crown manufactured from traditional impression (Gp II) and the lower gap in the crown created from the stone die on examining (Gp III).

Conclusion: Based on the aftereffects of the present research, it was inferred that advanced checking for monolithic zircon crowns acquired utilizing distinctive digitalscanning strategies gave a lower minimal gap or most extreme fit an incentive for three estimations in stone die

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INTRODUCTION

Impression is defined as a negative likeness or copy in reverse of the surface of an object; an imprint of the teeth and adjacent structures for use in dentistry". Impression procedure is the key for a successful restoration. Inaccurate impression can affect the fabrication o f a fitting dental restoration. The accurate impression will represent the oral anatomy upon which the final restoration will be placed. Impressions materials have passed throw a long series of modifications and enhancements to reach the maximum accuracy.[1-5] Many dental materials have been used as an impression material as plaster of paris, zinc oxide–eugenol, modeling compound, hydrocolloids and rubber impression materials.

These materials supported the fabrication of dental restorations for many years and each of them is suitable for specific restorations and specific mouth anatomy. [6-8]

The improvement of impression method was inspired by the developing variety of dental rebuilding efforts . Hydrocolloids and elastic base impression materials were the main decision as an impression materials for a long time particularly it is reasonable for most dental reclamations

Notwithstanding, a few disservices may happen amid this system, for example, inadequacies on impressions and stone throws; dimensional changes amid cleansing, stockpiling and transportation, incomplete or broad partition of the impression material from the plate and the impacts of surface dampness on subtle elements precision of the impressions[9]. Likewise, regular impression-taking may cause patients' uneasiness like queasiness, disagreeable taste, breathing trouble and teeth affectability.

With the introduction of the digital workflow in dentistry digital impression appeared in the mid 1980s as the solution that can overcome all the drawbacks of conventional impression technique.[10] Digital impression technique is an access to the CAD/CAM workflow while abutment and arch information are captured directly in patients' mouth by intraoral scanning. Intraoral scanning proved to have higher efficiency , more patient comfort ,decreased the time needed for fabrication of the dental restorations, facilitate the storage of data and it improved the communication between the clinician, the technician and the patient because the design of the restoration may starts immediately after the capture of the impression. [11-14]

Yuzbasioglu et al, evaluated the difference between digital and conventional impression techniques regarding patients' perception, treatment comfort, effectiveness and clinical outcomes. The digital impression was superior in all aspects.[8]

There are two methods for digital scanning, optical scanners and mechanical scanners. In optical scanning, there is a light source (light or laser) and a receptor unit then the computer calculate a three dimensional data set from the image on the receptor unit. 10=). Hoever there are some drawbacks as complicated mechanics; they are very expensive and have long processing time[15-17]

While in mechanical scanning ,the master cast is red mechanically line-by-line by means of a ruby ball and the three dimensional structure measured. The Procera Scanner from Nobel Biocare (Göteborg) is the only example for mechanical scanners in dentistry[18-20]

All dental 3D scanners are constructed on the same basic principle. Fundamentally,a 3D scanner consists of a light source, one or more cameras, and a motion system supporting several axes for positioning the scanned object towards the light source and camera(s).

The light source projects well-defined lines into the surface of the object, and the camera(s) acquire images of the lines. Based on the known

angle and distance between camera and light source (jointly called the scan head), the 3D position(s) where the projected light is reflected can be calculated using trigonometry.

This measurement-principle is known as "triangulation". The basic principle works with one camera only, but two cameras improve scan speed, accuracy and scan coverage18[8]

CEREC was the first commercially available digital impression system for use in the field of dentistry. Now systems like 3M Lava C.O.S., Cadent iTero, E4D Dentist, and 3Shape Trios are available. Each has a specific technique for making impressions. Some scanning systems, like 3M Lava C.O.S. and CEREC Bluecam, require the application of a titanium dioxide or magnesium oxide powder to the abutment teeth before scanning them in order to eliminate reflection and create a measurable surface .This powder has a thickness of 13-85 μm.

So, other systems like E4D Dentist, CEREC Omnicam, 3 Shape Trios, and Cadent iTero, do not require this powder layer because the scanner software can capture the shiny surfaces19,20

Another CAD/CAM method does not involve intraoral scanning, by using scan the conventional impressions without the need for stone master models. This is done by scanning the impression and replicate them in digital form; examples of a devices capable of doing this are the lab scanners 3Shape D900 and ZirkonzahnS600 ARTI ,this method eliminated the interference which may occur by the patients movement, saliva and blood contamination and limited mouth opening. [20]

In the mid 1990s, Nobel Biocare presented the primary all-ceramic item with (CAD/CAM) substructure. The core comprised of 99.9% alumina on which a feldspathic ceramic was layered. The substructure or full-shape restoration is processed from a strong square of ceramic material. Accessible

materials for the subtractive CAD/CAM preparing incorporate; silica-based ceramics, penetration ceramics, lithium-disilicate ceramics, and oxide elite ceramics.

While there is another strong material for fabrication of fixed restoration as Zirconium (Zr), it is a metal with the atomic number 40, first discovered in 1789 by the chemist MartinKlaproth. The material has a density of 6.49 g/cm^3, a melting point of 1852 and a boiling point of 3580.It has a hexagonal crystal structure and is grayish in color.

Many types of zirconia products and their milling/grinding technology; Milling at green stage (non-sintered) as Cercon base, Cercon (Degudent, Frankfurt, Germany) ,Lava Frame;Lava (3M ESPE, Seefeld, Germany), Hint-ELs Zirkon TPZ-G, DigiDent (Girrbach, Pforzheim, Germany) ZirkonZahn, Steger (Steger, Brunneck, Italy) Xavex G 100 Zirkon, Etkon (Etkon, Grafelfingen, Germany). [21-24]

Marginal fit evaluation of dental restorations

The more accurate the impression, the more fitting of the final restoration. Accurate marginal fit is a very critical factor that can affect the longevity of the restoration .This can be explained well when we see the problems which happens with ill-fitting restorations such as luting agent dissolution), caries hypersensitivity and periodontal inflammation .Caries have been shown to be the most common reason (36.8%) for crown failure according to a 3-year clinical survey study

There are many method for evaluation of the marginal and internal fit of the restoration.

In vitro methods, Replica Technique (RT).This technique can be used in vivo and in vitro by us-ing a light body silicone to fill the space between the crown and the tooth . After removal from the crown restorations, the replicas were segmented, and measurements of the film thickness were per-formed with a light microscope. It is a very simple

technique but its limitation is the possible distortion of silicone during examination steps[24-25]

Sectioning of the specimens ;this technique is used for evaluation of internal fit of the restoration by sectioning the specimens and then studying them under an optical microscope. The advantage of this technique is the accurate measurements; but the limitation of this method are ;sectioning of the specimens may disturbance or fracture will be made in the sections have a minimum thickness and this will decrease the area to be evaluated[26]

Stereomicroscope; Tan et al. used a stereomicroscope to evaluate the marginal discrepancies of restorations produced by different techniques[28]. They took a 1:1 photograph of each of four sides of the die using a digital camera mounted on a tripod. Calibrated digital measurement software was used to measure the marginal openings. Although this technique can be considered very reliable but its limitations are; any change in the camera angle may change the measurement . Over hanged restoration can not be evaluated because the microscope is set perpendicular to the margin of the restoration so the vertical overlap of the margin will show no vertical gap[29]

Computerized tomography (CT); Pelekanos et al. used CT multiple projections of a crown restoration were taken as the source rotated around it . A computer software used to analyze the projections and produce a 3dimensional image (3D) .This technique can offer images of the internal surface of the crowns and the margins with different angulations but its drawbacks are many as ;limited accuracy of CT microtomography compared to electron microscope and the difficulty to define the materials that have similar coefficients of absorption[30]

3D fit assessment for dental restorations; Holst et al. developed a new triple-scan protocol; using a non-contact scanner, three scans were performed: Coping, Master cast and Coping placed on master cast in a clinically correct dies were digitized, surface tessellation/triangulation language (STL) were generated with a scanner software for both the coping and the master cast then fitting of both (STL) of cofinal position .The coping and master ping and master cast will be made assisted by the previously scanned position of coping placed on master cast. Then the same software will determine the misfit between the cast and the coping. This triple scan technique eliminated the disadvantages of 2D measurements as it increased the accuracy of evaluation by reaching every point in the interface between the restoration and the die[31]

Evaluations of the quality of zirconium crowns fit have been done by looking at changed sorts of materials and CAD/CAM fabricating techniques . Although some studies have been already conducted there is no solid evaluation of the precision of advanced impression and its subsequent peripheral and inner fits.

In like manner, the point of this investigation was to evaluate the accuracy of fit. of different techniques for digital scanning either the prepared abutment or its impression, or the die by evaluating marginal and internal fit of monolithic zirconium crowns

The null hypothesis is that the zirconium crowns fabricated directly from intraoral digital impression GI) demonstrate equivalent or higher qualities for marginal fit than the crowns from scanning traditional impressions (G2) and scanning stone die (G3) .

MATERIALS AND METHODS

A Standardized Computer Numerical Control machine (CNC)* will be used to reduce a Stainless

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Steel die with slandered dimensions, an occluso-gingival height of 6 mm, a taper of 6° and 1 mm shoulder circumferentially. The overall diameter of the specimen at the base is 8-8.5 mm. Poly vinylesiloxan impression** was taken and poured with type 4 stone*** to obtain the die for the prepared specimen. The master die , the impression and the stone die were digitally scanned for fabrication of monolithic zircon crowns.

Three groups of zirconium crowns 10 crowns per each were fabricated as follow:

1. First group (Gp1) : Stainless Steel master die

2. Second group (Gp2): Poly vinylesiloxan impression of the master die

3. Third group (Gp3): Dental stone die for the master die.

Optical scanning of the stainless steel die and its impression and stone die:

The stainless steel die and its impressionwere sprayed with scan spray in order to decrease its glancing to make an accurate optical impression and the stone dies were not . Then theywas placed in the ZirkonZahn[R] optical scanner (S600 ARTI, Zircon-Zahn, An der Ahr 7, 39030 Gais BZ, Italy) .Zirkon-zahn[R] scanning software was used to scan the object from all surfaces reproducing the finest details.

Fabrication of the subtractive CAD/CAM zircon crowns :

The crown design was made by CAD/CAM software Fig 1. The design was transferred to a CAD/CAM milling machine (Zirkonzahn M5, ZirconZahn, An der Ahr 7,39030 Gais BZ, Italy)****to fabricate the crown .

All the frameworks were sintered to full density, in a special sintering furnace (LavaTMFur-nace 200) at a temperature of 1.500 °C. Once they had been delivered, all frameworks were examined for deformity.

Marginal gap evaluation:

All the milled crowns of all groups were seated on the prepared tooth . A specially designed device was machined in order to aid in specimen holding during gap evaluation. It consisted of 2 parts. A Fixed base portion; rectangular in shape (10 cm length of
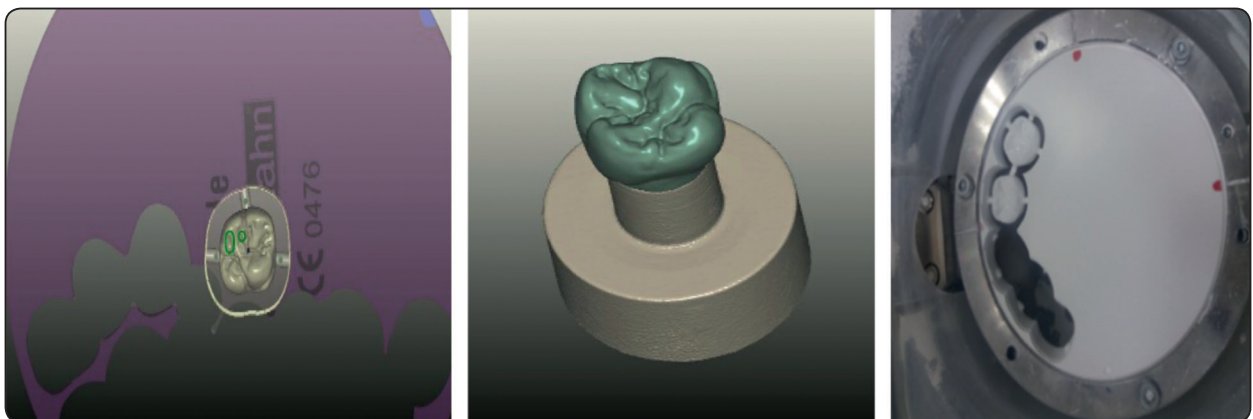

Fig. (1) Crown design in . Zirkonzahn[R] scanning software Milling of Zircon crown

1.2 cm height and 2.3 cm width). The specimen was rest on this portion and the upper movable portion rectangular in shape (10 cm length of 1.2 cm height and 2.3 cm width). This portion is connected to the base portion through 2 metallic rods surrounded by spring wire to control the compressibility of the upper portion after putting a constant weight on it. The upper is lined by rubber sheet to prevent friction that may cause any damage to the specimen.

Each specimen was photographed using USB Digital microscope with a built-in camera[*] connected with an IBM compatible personal computer using a fixed magnification of 45X.

A digital image analysis system[**] was used to measure and qualitatively evaluate the gap width. Within the Image J software, all limits, sizes, frames and measured parameters are expressed in pixels. Therefore, system calibration was done to convert the pixels into absolute real world units. Calibration was made by comparing an object of known size (a ruler in this study) with a scale generated by the Image J software. Specimens were held in place on their prepared molars using a specially designed and fabricated holding device. Shots of the margins were taken for each specimen. Then morphometric measurements were done for each shot 4equidistant landmarks along the cervical circumference for each surface of the specimen (Mesial, buccal, distal, and lingual). Then the data obtained were collected, tabulated and then subjected to statistical analysis.

RESULT

The data obtained were collected, tabulated in Table I that showed the means± standard deviation of the marginal gap of the fabricated crowns. The marginal gap $M \pm S.D$ (μm) of zircon crown that fabricated from digital scanning of the prepared molar (GpI) was 21.6173±9.615629 and that fabricated from scanning the conventional impression (Gp II) was 22.1335 ± 8.482116 while the crowns fabricated from the stone die scanning (Gp III) was 18.2960 ± 7.177245

One way ANOVA test was used to compare between the marginal gap of the three groups. Where P value was 0.09 . It was considered that there is no-significant difference between them.

While there is no significance but still the higher marginal gap was detected in the crown fabricated from conventional impression scanning (Gp II) and the lower gap in the crown fabricated from the stone die scanning (Gp III).

TABLE (I) Showing Means± Standard deviation of the marginal gap of the fabricated crowns.

Group	N	Mean	Std. Deviation	F	P-value
Master die(gpI) Conventional Impression (gpII)	40	21.6173	9.615629	2.410	.094
Stone die (gpIII)	40	22.1335	8.482116		
	40	18.2960	7.177245		
Total	120	20.6823	8.583667		

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* Scope Capture Digital Microscope, Guangdong, China.
** Image J 1.43U, National Institute of Health, USA

DISCUSSION

Monolithic zircon rebuilding may exhibit some clinical favorable circumstances over veneered zircon reclamations. Its high mechanical quality, cleaned monolithic zircon is the best contender for posterior FPDs within the sight of clinching or grinding. In any case, it ought to be noticed that despite the fact that the mechanical properties are still clinically satisfactory. Dental alteration strategies after cementation may likewise build the wear of opponent polish by expanding the surface hardness.

Restricted occlusal crown space might be another case in which monolithic zirconia ought to be utilized because of its higher break resistance contrasted with veneered partners and other monolithic ceramics even at least thicknesses. In spite of the fact that it has enhanced translucency, the impact of surface treatment and shaded fluid application methods on the shade of monolithic zirconia rebuilding efforts ought to be remembered while choosing the shade

In this study, USB Digital microscope with a built-in camera (Scope Capture Digital Microscope) connected with an IBM compatible personal computer using a fixed magnification of 45X. was use for marginal gap evaluation as this method is reliable and accurate because it eliminates interference of the clinician as in the replica technique which is more suitable for internal gap evaluation . Trifkovic et al; evaluated the application of electron microscope and Replica technique in marginal and internal gap measurements they found that electron microscope is reliable regarding marginal gap evaluation[40]

The present study used three different scanning methods; direct , conventional impression and die scanning. The degree of reflection of each surface to be scanned is different, so in scanning of the tooth structure and scanning of the conventional impression it was a must to use a scanning spray while in scanning of the stone model we did not have to use scanning spray because of the dull surface of the stone. So it was important to understand the prerequisite for each technique in order to achieve the most accurate results.

The results of the present study showed a lower marginal gap in the crowns fabricated from the stone die scanning (Gp III) was 18.2960 μm ,this very good result if compared with other digital impression with other groups ,direct scanning of the tooth or impression scanning(21.6173 and 22.1335 μm).Although their amount of marginal gaps were acceptable measures.

Accuracy of digital impression and its effect on marginal fit of crown restoration was evaluated in many studies before, Svanborg et al, compared marginal and internal fit of Cobalt-Chromium fixed bridge restoration made using digital and conventional impression technique, The results indicated that the digital impression technique is more exact and can generate 3-unit FDPs with a significantly closer fit compared to the conventional technique[39] ,this come in agreement with the results of present study.

Su TS et al, also compared marginal and internal fit of 3-unit ceramic fixed dental prostheses made with either a conventional or digital impression and the mean of marginal fit and internal fit values of the digital group were significantly smaller than those of the conventional group. So he concluded that CAD-CAM 3-unit zirconia FDP frameworks fabricated from intraoral digital and conventional impressions showed clinically acceptable marginal and internal fit. The marginal and internal fit of frameworks fabricated from the intraoral digital impression system were better than those fabricated from conventional impressions .[41] These studies are also agreed with the present study ,but the amounts of the gap was less ,this may be due to the monolithic fabrication technique of zirconium .

Pedroche et al, Also evaluated marginal and internal fit of zirconia copings obtained using

different digital scanning methods, the gap was evaluated at specific points and their results are confirm the present study. [42]

The intraoral and laboratory scanners may have not captured the data with the same degree of accuracy. In present study, direct impression is made using Zirkonzahn S600 ARTI® optical scanner which is a laboratory scanner, so the results can show some degree of difference if it was in vivo study using intraoral scanner, the accuracy of intraoral and extraoral scanners was evaluated by Flugge TV et al; who concluded that the intraoral scanner was less precise, because of the conditions of the oral cavity, such as the presence of saliva and limited access by the scanner.[43]This result should be taken into consideration when analyzing our results, because this was a laboratory study that was not subject to the influence of such factors.

CONCLUSION

Based on the results of the present research, it was concluded that digital scanning for monolithic zircon crowns obtained using different digital scanning methods provided a lower marginal gap value for three measurement in stone casts scanning, in comparison with conventional impressions and direct scanned tooth with a standard bench top laboratory scanner.

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