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ORIGINAL RESEARCH PAPER

Dentistry

EFFECT OF DIFFERENT DIGITAL IMPRESSION TECHNIQUES ON MARGINAL FIT OF ZIRCONIA CROWNS

KEY WORDS: CAD/CAM, 3D printing, monolithic zirconium, optical impression techniques.

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ABSTRACT

Purpose: This study was performed to evaluate the effect of different methods of digital impression techniques on the marginal adaptation of monolithic zircon crown restorations. **Materials and Methods:** Three groups of zirconia crowns, 10 crowns in each group, were as follows: 1)First group (G1) :Optical scanningof the stainless steel die (represent the natural tooth) using Zirkonzahn S600 ARTI®.optical scanner after it is sprayed with scanning spray gave us an optical impression from which we fabricated zirconium crowns directly. 2)Second group (G2): Polyvinylsiloxane impression material was used for fabrication of the conventional impression then digitized by optical scanning, then CAD/CAM was used to get zirconium crowns. 3)Third group (G3): Dental stone die, was scanned to produce the zirconium crowns. **Results:** The marginal gap (M ± S.D., µm) of zirconia crowns fabricated using the digital impression for the master die (G1) was 21.62 ± 9.62, those fabricated from scanning the conventional impression (G2) was 22.13 ± 8.48, and those fabricated from scanning the stone die (G3) was 18.30 ± 7.18. A one-way ANOVA test was used to compare the marginal gaps of the three groups, where the P value was 0.09. It was considered that there is no-significant difference between them. While there was no significant difference, the highest marginal gap was observed in the crowns fabricated from conventional impression scanning (Group II), and the lowest gap was observed in the crowns fabricated from stone die scanning (Group III). **Research hypotheses:** HO: There is no difference in the marginal fit of the three groups of crown restorations. HA: There is a difference in the marginal fit of the three groups.

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 of a fitting dental restoration. The accurate impression will represent the oral anatomy upon which the final restoration will be placed.Impression 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 .[6-7]

The development of impression procedures was driven by the increasing variety of dental restorations. Hydrocolloids and rubber base impression materials was the first choice as an impression material for many years especially it is suitable for most dental restorations

However, several disadvantages may occur during this procedure, such as deficiencies on impressions and stone casts; dimensional changes of impressions and stone casts during disinfection, storage and transportation; partial or extensive separation of the impression material from the tray; the effects of surface moisture on details accuracy of the impressions[9].

In addition, conventional impression-taking may cause patients' discomfort like nausea, unpleasant taste, breathing difficulty and teeth sensitivity.[10]

With the introduction of the digital workflow in dentistry digital impression appeared in the mid 1980s as the solution which can overcome all the drawbacks of conventional impression technique.

Digital impression technique is also an access to the CAD/CAM workflow that 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.[15]

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. Examples of optical scanners on the dental market: Lava scans ST (3M ESPE, white light projections), Everest scan (kavo, white light projections). While there are some drawbacks as complicated mechanics, very expensive and long processing time.[16-17]

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 coverage.[18]

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 for example. 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 m. 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 surfaces. 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 my occur by the patients movement, saliva and blood contamination and limited mouth opening.[19-20]

In the mid 1990s, Nobel Biocare introduced the first all-ceramic product with (CAD/CAM) substructure. The core consisted of 99.9% alumina on which a feldspathic ceramic was layered.[7] The substructure or full-contour restoration is milled from a solid block of ceramic material. Available materials for the subtractive CAD/CAM processing include silica-based ceramics, infiltration ceramics, lithium-disilicate ceramics, and oxide high-performance 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/cm³, amelting point of 1852 ℃ and a boiling point of 3580 ℃.It has a hexagonal crystal structure and is grayish in color.

Three types of zirconia products and their milling/grinding technology:Milling at green stage (non-sintered):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 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 by Schwartz et al.[25-30]

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 using 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 performed with a light microscope. It is a very simple technique but its limitation is the possible distortion of silicone during examination steps.[31-32]

Sectioning of the specimens ;this technique is used 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 therefore, duplicates will be made and the sections have a minimum thickness and this will decrease the area to be evaluated.[31-33]

Stereomicroscope ; Tan et al; [18] used a stereomicroscope to evaluate the marginal discrepancies of restorations produced by different techniques .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 .Overhanged 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[34]

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 like ;limited accuracy of CT microtomography compared to electron microscope and the difficulty to define the materials that have similar coefficients of absorption.[35]

3D fit assessment for dental restorations; Holst et al. developed a new triple-scan protocol; using a non-contact scanner, three scans were performed: 1) Coping 2) Master cast and 3) Coping placed on master cast in a clinically correct final position .The coping and master 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 coping 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[33-36]

Evaluations of the quality of zirconium crowns fit have been carried out by comparing different types of materials and CAD/CAM manufacturing systems . Although some studies have been already conducted, there is no solid evaluation of the accuracy of digital impression and its resulting marginal and internal fits. Accordingly, the aim of this study was to assess the precision of fit of different techniques for digital scanning either the prepared abutment or its impression, or the die by evaluating marginal fit of monolithic zirconium crowns.[33,34]

The null hypothesis is that the zirconium crowns fabricated directly from intraoral digital impression (group GI) show equal or higher values for marginal fit than the crowns from scanning conventional impressions (group G2) and scanning stone die (group G3) . The alternative hypothesis is that the crowns from (group GI)show lower values for marginal and internal fit than the other groups.[37-38]

MATERIALS :

VenilePolysiloxane impression material :Imprint™ IIPenta™ Heavy Body used incombination with Imprint II Garant™light body manufactured by 3M®.Type four dental stone and zirconium block for milling:Prettau® Zirconia manufactured by Zirkonzahn®

METHODS:

A standardized Computer Numerical Control machine (CNC) was used to fabricate a stainless steel master die simulating a prepared crown with an occluso-gingival height of 6 mm, a taper of 6° and 1 mm shoulder circumferentially. The overall diameter of the die at the base is 8.5 mm8.

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

1)First group (G1) :Optical scanningof the stainless steel die (represent the natural tooth) using Zirkonzahn S600 ARTI®.optical scanner after it is sprayed with scanning spray gave us an optical impression from which we fabricated zirconium crowns directly . [figure 1]

Fig. 1

2) Second Group (G2): Polyvinylsiloxane impression material was used for fabrication of the conventional impression then digitizedby optical scanning then CAD/CAM was used to get zirconium crowns . [fig 2]

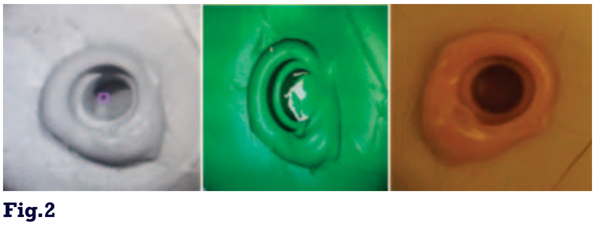

Fig.2

3) Third Group (G3): dental stone die, was scanned to produce the zirconium crowns. Fig.3

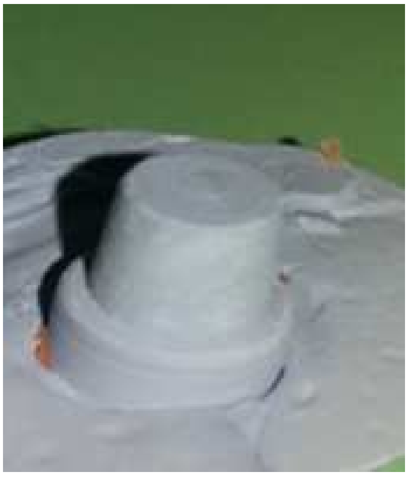

Fig.3

After CAD of the crowns is obtained using Zirkonzahn software, the crowns of all groups were milled from semi-sintered zirconia, by Zirkonzahn®Milling Unit M3. [fig.4]

After milling, all the frameworks were sinteredto 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 and debris.

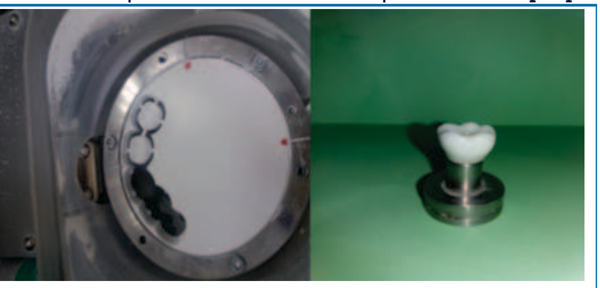

Fig.4

Marginal Gap Evaluation:

Holding device: [fig.5]

A specially designed device was machined from wood in order to aid in specimen holding during gap evaluation. It consisted of 2 parts (A-B)

A: Fixed base portion; rectangular in shape (10 cm length of 1.2 cm height and 2.3 cm width). The stainless steel die will rest on this portion.

B: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 and fixed by tightening plastic caps. Also it is lined by rubber sheet to prevent friction that may cause any damage to the specimen

Fig.5

Each specimen was photographed using USB Digital microscope with a built-in camera (Scope Capture Digital Microscope, Guangdong, China) connected with an IBM compatible personal computer using a fixed magnification of 45X. [fig.6]

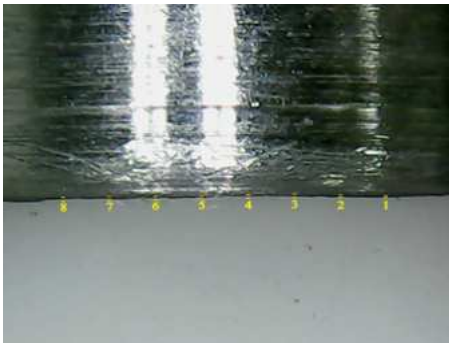

Fig.6

A digital image analysis system (Image J 1.43U, National Institute of Health, USA) 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)(figure 4) with a scale generated by the Image J software. Specimens were held in place over their corresponding dies using a specially designed and fabricated holding device (Figure). Shots of the margins were taken for each specimen. Then morphometric measurements were done for each shot [8 equidistant 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 crown.

The marginal gap M ± S.D (μm) of zircon crown that fabricated from digital impression for the master die (gpI) was 21.6173±9.615629 ,fabricated from scanning the conventional impression (G2) was 22.1335 ± 8.482116 while fabricated from the stone die scanning (G3) was 18.2960 ± 7.177245

One way ANOVA test was used to compare between the marginal gap of the three gps. 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, group II and the lower gap in the crown fabricated from the stone die scanning group III. [table 1]

Table:1

Group	N	Mean	Std. Deviation	F	P-value
Direct 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		

DISCUSSION

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 VPS technique.[39]

Su TS et al, Compared marginal and internal fit of 3-unit ceramic fixed dental prostheses made with either a conventional or digital impression and the mean marginal fit values of the digital group (64 ±16 m) were significantly smaller than those of the conventional group (76 ±18 m) (P<.05). The mean internal fit values of the digital group (111 ±34 m) were significantly smaller than those of the conventional group (132 ±44 m) (P<.05) 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.(40)

Pedroche et al, evaluated marginal and internal fit of zirconia copings obtained using different digital scanning methods,including direct scanning ,scanning of impression and scanning of stone cast. The gap was evaluated at specific points, (1)marginal gap (MG): perpendicular distance from the internal surface at the margin of the coping to the prepared tooth. (2)axial wall (AW): discrepancy between the prepared tooth and internal surface of the coping at the mid-axial wall. (3) axial-occlusal angle (AO): discrepancy between the prepared tooth and internal surface of the coping in the region of the axial-occlusal edge, at the point of intersection of two straight lines: one parallel to the occlusal plane and the other parallel to the axial wall.(4)centro-occlusal area (CO): discrepancy between the prepared tooth and internal surface of the coping in the center of the occlusalregion.Therefore, 16 measurements were obtained for each replica, i.e. four measurements for each point. The data showed statistically significant differences based on the digital scanning methods for MG, AO and CO. There was no statistically significant difference among the gap values for AW.

Regarding MG, intraoral digital scanning showed lower gap values and gypsum model scanning showed higher gap values. Polyvinyl siloxane impression scanning showed intermediate misfit values. Regarding AO and CO, intraoral digital scanning also showed lower gap values. Polyvinyl siloxane impression scanning and gypsum model scanning showed higher gap values and were statistically similar.(41) the longevity of indirect restoration is highly related to the smallest marginal gap.the acceptable marginal gap shouldn't exceed 120μm(43)

In the present study ,USB Digital microscope with a built-in camera (Scope Capture Digital Microscope, Guangdong, China) 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 . Trifkovicetal; 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.(44)

The present study used three different scaning techniques: direct scanning ,sanning of impression an scanning of the model. the degree of reflection of each surface to be scanned is different so in scanning of the stainless steel die and scanning of the PVS 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 intraoral and laboratory scanners may not have captured the data with the same degree of accuracy.In this 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 TVetal;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.(42)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 :

The results of the present research, concluded that digital scanning for monolithic zircon crowns provided a lower marginal gap value measurement in stone casts scanning, in comparison with conventional impressions and direct scanned tooth with a standard bench top scanner

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