



Comparison the marginal and internal fitness of veneered and anatomical zirconia crowns milled by two different CAD/CAM systems (An in Vitro Study)

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Abstract

Background: Accuracy of fit is considered a very important factor in a crown fabricating procedure. Zirconium oxide ceramic is gaining popularity because of its remarkable mechanical capabilities and the potential aesthetic results obtained by using its recommended veneering porcelain, this study aimed to determine the effect of porcelain veneering on the marginal and internal fitness of zirconium-oxide crowns milled with two different CAD/CAM systems (Wet and dry milling).

Materials and methods: An ideal prepared tooth #16 to receive an all-ceramic crown restoration with 0.8mm chamfer finishing line was used as a master die. It duplicated and poured to get thirty-two stone working dies. The stone dies divided into two major groups according to the CAD/CAM systems being used, then each group subdivided into two subgroups (n=8) either zirconia crowns milled to full contour or traditional veneered zirconia crowns. Each crown then cemented to it stone die and sectioned longitudinally into four pieces. Stereomicroscope with aid of (image J) was used to examine the sample at a magnification of (140X). Four points of measurement were selected at each of the four-sectioned parts.

Results: The final internal gap value of each sample was the arithmetical mean of the selected points of the four-sectioned pieces The data was evaluated statistically, using One-way ANOVA and LSD tests which revealed highly significant differences ($p < 0.001$) among groups.

Conclusion: Full-contoured zirconia crowns have better marginal and internal fit than the traditionally veneered crown, (CEREC AC, Sirona) system showed the best internal fitness. The mean gap of all groups was within the clinically acceptance.

Keywords: Internal fitness, Zirconia, CAD/CAM.

Introduction

Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) is a three-dimensional scanning technology used in dentistry in order to increase productivity and patient satisfaction ⁽¹⁾. The CAD/CAM technology is quickly rising in popularity. It developed to abolish the need for the traditional impression taking, pouring, and many of laboratory-shaping steps of fabricating crowns. An advanced scanner, a computerized milling machine, and a sintering oven, as well as CAD/CAM software applications, are among

the techniques utilized in the manufacture of all-ceramic systems in a dental laboratory. ^(1,2).

In restorative dentistry, the advancement of dental ceramic materials has led to the use of partially stabilized zirconia, which may be created using (CAD/CAM) systems. Because of zirconia's superior strength and fracture toughness when compared to other dental ceramic systems, it's becoming widely preferred for dental restorations. ^(3,4).

In dentistry, there are many companies providing zirconia materials; these materials, which include 3% yttrium oxide tetragonal

zirconia polycrystals, are chemically identical. In some cases, alumina of small concentration (0.25%) are added. Although, the zirconia-based ceramics are chemically similar, they can reveal different mechanical and optical properties, once processed. Working with zirconia blocks can be differing in type of milling (e.g., wet milling or dry milling) and in the temperature and time of sintering programs^(5, 6). The pre-sintered zirconia is milled, when it has soft and chalk-like consistency. It is sintered again after milling to reach the full density. The translucency of zirconia is differed also; some zirconia blocks exhibit a bright white color, rather opaque while others do not⁽⁷⁾. The zirconia framework also can achieve optimal esthetics (translucency & color) when covered with perfectly matching overlay porcelain⁽⁸⁾.

One of the most essential aspects of prosthetic restorations is marginal adaptation, which refers to the distance between the restoration edge and the tooth's margins, or the degree to which the inner side of a tooth is close to and interlocked with the tooth's wall. Poor marginal adaptation reduces the efficacy of the restoration, shortens its lifespan, and increases the risk of recurrent caries and periodontal problems⁽⁹⁾. It can also dissolve the cement, allowing fluids and germs to escape through the interface between the crown and the cavity preparation walls. This result in marginal discoloration, pulpal irritation, and secondary carious lesion⁽¹⁰⁾.

This study aimed to determine the effect of porcelain veneering on the marginal and internal fitness of zirconium-oxide crowns milled with two different CAD/CAM systems (dry and wet milling) and to compare the fitness of the traditionally veneered and that of full contoured zirconia crowns.

Materials And Methods

An ideal prepared tooth #16 (right maxillary molar)(Fig.1) with 0.8mm chamfer finishing line, rounded internal angles and 2mm occlusal reduction was used as a master die. It duplicated by using an additional silicon impression material (heavy and light viscosity) and poured with stone type IV (Zhermack, Italy) to get thirty-two stone working dies. The stone dies divided into two major groups according to the CAD/CAM systems being used, then each group subdivided into two subgroups (n=8), zirconia crowns milled to full contour or traditional veneered zirconia crowns (Fig 2).

Each stone die was scanned and the crown design was determined with the aid of special software modulator either for coping or anatomical crown design, the information of the complete design sent to the milling machine to be milled on the selected suitable zirconia blanks for each systems.

After complete milling procedure, the crowns separated from their blanks by using separating disc with engine, then placed on the jar of the furnace of each systems to complete sintering. Zirconia copings were veneered with GC initial porcelain and placed in computerized porcelain furnace (programat p80, Ivoclar Vivadent). All these procedures were done according to manufacture instructions.

Crowns luting and sectioning procedure

Glass ionomer cement was used for cementation and a drop of red dye was added to the mixture, then the internal surfaces of the crowns were painted with the mixed cement. Crowns were initially positioned on their working dies with finger pressure and a constant 5-Kg load was applied on each crown for 10 minutes, dental surveyor (Saeshin, Germany) was used for this purpose⁽¹¹⁾ (Fig. 3). The cemented crowns with their stone dies covered with clear acrylic to support them during sectioning. Each die-crown unit, which had already been blocked with acrylic, was sliced into four parts longitudinally utilizing sectioning device that specially designated for this purpose (Fig. 4). Cutting at high speed with water coolant was done with a diamond disk with a thickness of 0.01 mm. The sample is dissected mesiodistally by the first cut; the second cut divides the sample buccolingually. The two cuts were perpendicular to the sample's long axis.; This was accomplished by marking the sample's long axis with a marker pen on the surveyor's analyzing rod.⁽¹²⁾

Internal gap measurements

Stereo microscope with microscopically camera (ST 60 Series, Germany) connected to the computer was used to examine the sample. The microscope was calibrated at a magnification of (140X) and the image treated with image processing program (image J).

Four points of measurement were selected at each of the four sectioned part (mid-occlusal (P₁), mid angle (P₂), mid axial (P₃), and at the margin (P₄)). Internal gap values had been obtained by measuring the space between the inner side of the crown and the die that

attaches to it, at each of the previously selected four points of each surface of the four parts that resulted from the cutting⁽¹³⁾ (Figure 5).

The gap was measured with image J, all values recorded in pixels and converted to micron by the same program. The final internal discrepancy value of each sample was the arithmetical mean of these points of four sectioned parts.

RESULTS

For each of the four groups, the mean, standard deviation, minimum, and maximum mean values of the internal gap are displayed in (Table 1) (Figure 6). The results of the ANOVA test for both the marginal gap and internal fitness are shown in (Table 2). LSD test after ANOVA is shown in (Table 3). The result showed that the highest mean of internal gap was scored by group II (Veneered zirconia, Amman Girbach) (75.59um), While the lowest mean was recorded by group III (Full contoured zirconia, Sirona) (40.83um).

From (table 2 and 3) it has been found that the difference in the internal gap among the four groups was statistically highly significant.

DISCUSSION

Good marginal and internal adaptation has been found to be critical for long-term crown restoration efficiency. Cement disintegration, microleakage, marginal discoloration, and secondary cavities can all result from a poor marginal fit. While, internal adaptation is also important as it affects crown seating, thus good adaptation will facilitate seating of the crown and improve both retention and resistance of the restoration⁽¹⁴⁾. In this *in vitro* study, the accuracy of marginal and internal fit of traditionally-veneered and full-anatomical zirconia crowns that milled by two different CAD/CAM systems was determined.

Moreover, the data of occlusal point (P₁) showed the highest values of discrepancy. While the mid-axial point (p₃) showed the smallest discrepancy, this may be due the plane part without curves of axial surfaces thus; more precise scan data can be obtained than in the anatomical curved areas. The acceptable internal gap of all-ceramic crowns has been reported to be between 49 and 136 um^(14, 19). In this study type IV die stone was used which has

All crowns were cemented with glass ionomer luting agent, since it considered a traditional luting agent, with simple cementation process and have the advantage of success for many years⁽¹⁵⁾. For standardization and achieving good flow of the cement, the sample was loaded by 5Kg during the setting time⁽¹⁶⁾. Furthermore, a red stain was added to allow good distinguishing of the tooth colored luting agent.

Sectioning method with selection of adequate points for each section was utilized to measure the marginal and internal gaps with the use of a stereomicroscope at (140X) magnification and the (image J) program, since it allowed direct view of the cement thickness⁽¹⁷⁾.

In this study, the full-contour zirconia crowns (group I, III) showed lower mean gaps compared to the veneered groups (II, IV) and this may attributed to the fact that the later groups undergo additional firing cycles during veneering process that may cause residual stresses as the porcelain contracts, which may lead to distortion of the underlying zirconia frameworks. This coincide with Atta A and Sabea in (2013)⁽¹⁸⁾, who stated that full-contour zirconia (Zolid) had better adaptation than veneered zirconia.

The results of this study, showed that the zirconia crowns fabricated with (Cerec AC, Sirona) system had lower gaps compared to that of (Amman Girbach, Germany) CAD/CAM system. This may be related to the difference in the accuracy of scanner device and software of each system, or it may be related to the difference in the materials blocks and/or the manner of milling machine (wet milling for sirona Vs dry milling for the other system). Since, the wet milling of high degree-pre sintered zirconia blocks proved to have good accuracy and less degree of distortion that may occur due to heat generation of dry milling⁽¹⁴⁾.

high strength and low expansion that allow easy separation of the working cast from the impression without chipping. Nevertheless, there was a chance of fracture/chipping during sectioning; therefore, each specimen was covered by clear acrylic to avoid such scenario.

Conflicts of Interest

The authors reported that they have no conflicts of interest.

Conclusion

The following conclusions can be drawn from this in vitro study within its limitations:

1. The full-Anatomical crowns have better marginal and internal gaps than that of traditionally-veneered zirconia crowns.
2. Sirona CAD/CAM systems have less marginal and internal discrepancy.
3. All groups are clinically acceptable.

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Table (1): Descriptive statistics of the internal gap (μm) in each group

Groups	N	Mean	\pm S.D.	Min.	Max.
I	8	61.15	2.22	57.87	64.18
II	8	75.59	1.48	73.25	77.25
III	8	40.83	1.20	39.06	42.31
IV	8	54.79	2.56	52	59.25

(Table 2) Groups' difference using ANOVA test

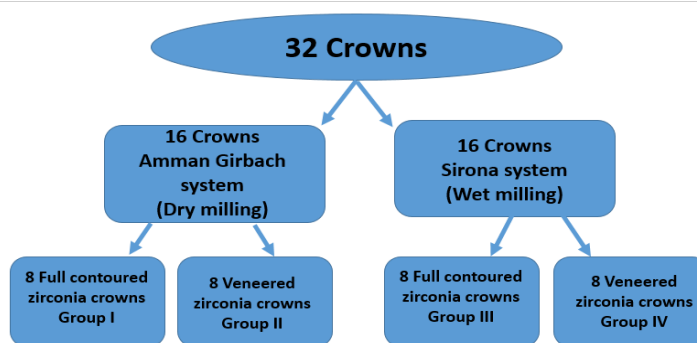
ANOVA	Sum of Squares	d.f.	Mean Square	F-test	p-value
Between Groups	4994.969	3	1664.990	440.609	<0.001 (HS)
Within Groups	105.807	28	3.779		
Total	5100.777	31			

(Table 3) LSD test between each two groups

Groups		Mean Difference	p-value
I	II	-14.44	< 0.001 (HS)
	III	20.32	< 0.001 (HS)
	IV	6.35	< 0.001 (HS)
II	III	34.76	< 0.001 (HS)
	IV	20.80	< 0.001 (HS)
III	IV	-13.96	< 0.001 (HS)



(Figure 1) Master die



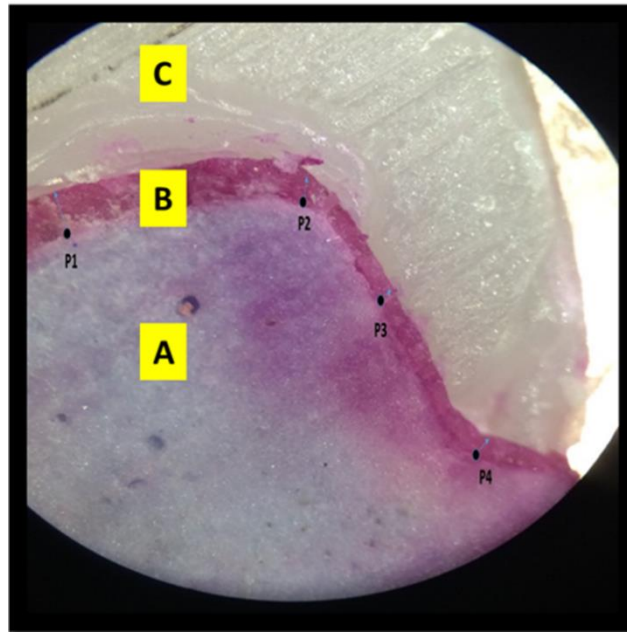
(Figure 2) Sample grouping



(Figure 3) Five-Kg load applied on each crown during setting time of the cement



(Fig. 4) The specially designated sectioning device



(Figure 5): Internal gap: A: Stone die, B: cement, C: zirconia crown

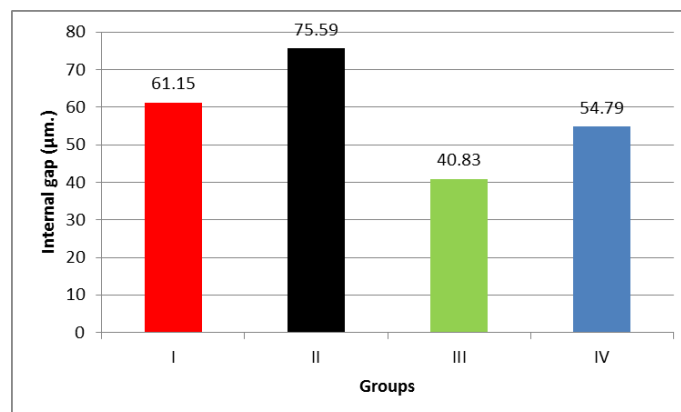


Figure (6): Bar-chart showing the mean values of the internal gap of all groups