Research Article

Crystallization firing effect on the marginal discrepancy of the IPS. emax CAD crowns using two different CAD/CAM systems

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Abstract: Background: Marginal adaptation is critical for long – term success of crown and bridge restoration. Computer aided design / computer aided manufacture (CAD/ CAM) system is gaining more importance in the fabrication of dental restoration. Objective: The aim of this study is to evaluate the effect of crystallization firing on the vertical marginal gap of IPS. emax CAD crowns which fabricated with two different CAD/CAM systems .Materials and Methods: Twenty IPS e.max CAD crowns were fabricated. We had two major groups (A, B) (10 crowns for each group) according to the CAD/CAM system being used: Group A: fabricated with Imes - Icore CAD/CAM system; Group B: fabricated with In Lab Sirona CAD/CAM system. Each group was subdivided into two subgroups pre-crystallized (Group A1, B1) and crystallized crowns (Group A2, B2). At four points on each aspect of the crown, marginal gaps were assessed on the master metal die by using digital microscope at a magnification of (110X) and image- J program. The measurement was done twice for each crown; before and after crystallization process.Results: The lowest mean of marginal gap before and after crystallization was (29.387±2.774µm) and (70.108±5.569µm) respectively for Group A (Imes - Icore system) and the highest mean value before and after crystallization was (51.728 ±3.774µm) and (84.071 ±4.567µm) respectively for Group B (Sirona system). Paired sample t-test result showed a statistically highly significant difference in marginal gap between all groups.Conclusions: The crystallization process increases the vertical marginal gap. Imes - Icore system showed the lower marginal gap than Sirona system. The two systems have an acceptable marginal gap

.**Keywords:** IPS. emax CAD, CAD/CAM system, Marginal discrepancy, Crystallization firing

Introduction

The marginal gap is defined as the vertical distance between the preparation's finishing line and the cervical edge of the restoration [(1)]. Poor adaptation and an excessively large gap , which may result in cement dissolution, allowing saliva , food debris , and oral bacteria to seep along the gap between the restoration and the preparations walls , raising the risk of dental caries and periodontal disease [(2)].

Both clinicians and patients have shown interest in metal-free biocompatible restorations, prompting researchers to look for alternatives. All ceramic restorations with excellent biocompatibility, colour consistency, high wear resistance, and superior light transmissivity have been created to meet this need [(3)].

There are numerous ceramic systems available, which may vary in composition or manufacturing technique. Lithium disilicate and zirconia-based systems are two of the most widely used products in clinical practice. Prefabricated blocks milled with a CAD/CAM device can be used to make the restoration [(4)].

Lithium disilicate blocks are easier to mill because they are initially partially sintered and relatively soft. This material requires crystallization after milling procedure , which is normally accompanied with a 0.2% shrinkage accounted for by the designing program [5].

In 2005 Ivoclar Vivadent introduced IPS e.max CAD as an enhanced ceramic material optimized for CAD/CAM processing. It is made of lithium disilicatereinforced glass ceramic, but its physical characteristics and translucency are improved [6]. In the field of fixed partial denture ,the progress of CAD/CAM provided to the dentist newer and faster treatment options . The CAD-CAM system used to scan , design and mill the restoration . Two types of CAD/CAM systems were presented in the market ,the clinic (in-office) and (in –lab) systems [7]. Many factors can affect the precision and fit of dental ceramic restoration such as firing cycle, fabrication technique, scanning unit, milling device, size and type of milling instruments, and type milling procedure [8].

The purpose of this study was to assessed the effect of crystallization firing on the marginal discrepancy of IPSe.max CAD crowns fabricated by two different CAD/ CAM systems. The null hypothesis was that crystallization firing and different CAD/CAM systems have no effect on the marginal discrepancy of IPSe.max CAD crowns.

Materials and Methods

Die Fabrication

A prepared plastic mandibular right first molar (Nissin Dental Products ,Kyoto Japan) with rounded shoulder finishing line of uniform thickness of 1mm, axial and occlusal reduction of about1.5mm was used for the construction of a master metal die several CAD/CAM studies have used master metal dies [9-12]. The master metal die resist the wear during fabrication procedures and measurements [10].The metal die was fabricated by using CAD / CAM system to simulate the shape of ideal prepared plastic tooth to receive the all ceramic crowns[12].

The plastic prepared die was scanned with white light scanner (DOF ,full HD , 2 M pixel /,Korea),then the digital model of the die transferred to the CAM software to start the milling process of the metal die by using the milling unit (VHF S1 ,K5 impression machine , Germany) which was loaded with cobalt chromium disc (10 mm)(Interdent,Travagliato (BS) Italy).

The base of metal dies was made by placing the metal die in the plastic ring and pouring the dental stone type IV (Syna Rock , Italy) to 3 mm below the finishing line . Metal die with stone base (Figure1).

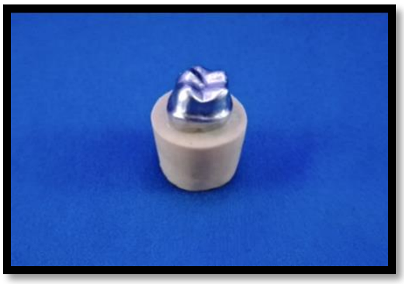

Figure 1: The final metal die with stone base

Twenty crowns were introduced in this study which is divided into two groups based on the CAD/CAM system used for crown fabrication ,group A: 10 crowns were fabricated with (Imes - Icore CAD/CAM system),group B: 10 crowns were fabricated with (In Lab Sirona CAD/CAM system).Each group then subdivided into two subgroups (pre- crystallized IPSe.max CAD crowns) and (crystallized IPSe.max CAD crowns).

Crowns fabrication

Glass ceramic block of lithium disilicate (IPSe.max CAD LT B2/C14,Ivoclar Vivadent, Schaan, Liechtenstein) was used to produce all ceramic crown. Twenty IPSe.max CAD crowns were fabricated by using two different CAD/CAM systems, Imes- Icore dental system (250i 5 axis ,GmbH, Leibolzgraben, Germany) , and InLab Sirona Dental System (4 axis ,GmbH, Bensheim, Germany).All construction steps including metal die scanning, designing of software and milling were accomplished according to the instruction of manufacturer for each IPSe.max CAD block and CAD/CAM systems.

The crowns characteristics were equal and fixed to have cement space of 50μm and adhesive space of 100μm from the finishing line .Crystallization firing was carried out at 850°C for 25 minutes in a porcelain furnace (EP3010,Ivoclar vivadent , Schaan ,Liechtenstein) according to the manufacturer's instructions. Exclusive trays and pins were utilized in conjunction with IPS object fix putty (Ivoclar vivadent , Schaan ,Liechtenstein) (7) .

Each of the tested crowns was seated on the metal die and inspected for vertical marginal gap, using digital microscope (Dino- lite , Taiwan) at magnification of 110x. Four midline were drawn in the center of crown and metal die, and four point were marked on each surface of the metal die and crown (two points at the border of the center line while the other points were at a distance of 1mm from the points mentioned on both left and right sides (8).

A custom designed specimen holding device , consisting of a screw holding portion with a load sensor, was utilized to keep the crowns in correct position on the metal die during measurement and to apply pressure (5 Kg) , the margins' digital images were captured and evaluated using image processing program (Image J). The marginal gap of the 20 crowns was measured before and after crystallization firing, 320 measurements for each system ,thus yielding 640 measurements in all.

Results

The vertical marginal gap of crowns were measured twice; before and after crystallization .A1, B1, (before crystallization).A2, B2, (after crystallization).The lowest vertical marginal gap mean(29.387± 2.774μm) was scored by Imes-Icore system crown before crystallization (Group A1) , while Sirona system crown after crystallization(Group B2) presented the highest mean value (84.071± 4.567 μm) (Table.1) .

The mean and standard deviation values of the marginal gap before and after the crystallization process showed that the marginal gap was larger after the crystallization firing and this difference was highly statistically significant (Table.2).

The analysis was performed using the Paired sample t-test between each of the two subgroups of the two systems and the difference in vertical marginal gap between the two different CAD/CAM systems was highly statistically significant (P<0.01) (Table .3).

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

Systems	Groups	N	Mean	S.D.	Min.	Max.
Imes-Icore system	A1	10	29.387	2.774	25.063	33.811
	A2	10	70.108	5.569	62.637	77.263
Sirona System	B1	10	51.728	3.774	45.472	57.273
	B2	10	84.071	4.567	77.211	89.580

Table 2: Descriptive statistics and effect of crystallization on the marginal gap

Groups	Before crystallization		After crystallization		Effect of crystallization (d.f..=9)		
	Mean	S.D.	Mean	S.D.	Mean difference	t-test	P-Value
A1 vs. A2	29.387	2.774	70.108	5.569	-40.721	-23.087	0.000 (HS)
B1 vs. B2	51.728	3.774	84.071	4.567	-32.343	-18.401	0.000 (HS)

Table 3: The Paired sample T- test for effect of different CAD/ CAM on the marginal gap

Groups	Mean	S.D.	Mean difference	t-test	P-Value
A1	29.387	2.774	-22.341	-23.087	0.000 (HS)
B1	51.728	3.774			
A2	70.108	5.569	-13.963	-18.401	0.000 (HS)
B2	84.071	4.567			

Discussion

Marginal gap (MG) is defined as the measurement between finishing line of the preparation and margin of the crown [9]. The minimization of marginal gap of crown is an important feature in prosthodontics dentistry that can contribute to clinically long term success of the restoration [10].

The CAD / CAM systems are used in the manipulation of ceramics, such as zirconia or glass ceramics , as well as, this technology have the ability to produce an accurate fit and individual design, simple handling characteristics, and time consuming production processes; in addition to that, the components of CAD/CAM system are extremely homogenous and biocompatible[11].

Lithium disilicate ceramics are used for restoring anterior and posterior single crowns and because they have the advantage of minimum linear shrinkage , they have been employed for a variety of applications including single crowns for implants , inlays, onlays, and laminate veneer prosthesis [12].

In this study, an ideal prepared plastic tooth#46 with rounded shoulder finishing line was selected which enable more accurate seating of the crown [13].

Several studies have shown that clinically acceptable margins can be achieved using either a chamfer or a shoulder finishing line [14]. The metal die was fabricated by using CAD/CAM to simulate the shape of an ideal prepared plastic tooth to receive the all ceramic crowns [15].

In this study, a specimen holding device was specially designed to hold the IPSe.maxCAD crowns on the metal die on the microscope stage during measurement .Furthermore, this device designed to have a load sensor connected to digital numerical device ,in order to ensure that a uniform standard load of (5 kg) was applied on each crown during measurement [16-18].

Each crown had sixteen marginal gap assessment sites , the measurement of vertical marginal are made at four point on each crown sides [10, 19]. In the current study digital microscope was used for marginal measurement , this measurement method did not include any procedures such as sectioning or replication of the cement space before measurement the marginal gap ,making it less expensive non-destructive , less time consuming than other techniques and reducing the risk of error accumulation that can occur when multiple procedures are used [19-21].

After a clinical assessment of more than 1000 crowns over a 5 years period, several authors estimated maximum marginal opening values and concluded that a marginal gap of no more than 120μm is clinically acceptable [22] .The acceptable marginal gap discrepancies for CAD/CAM crowns are reported between 50 to 100μm [14, 23-25].

The result of this study showed that it was a high significant increasing effect on the marginal gap of both groups (A,B) after crystallization, this finding comes in agreement with Kim,Oh et al and Azarbal A. et al [26, 27]. This effect could be attributed to the fact that the material prior to crystallization is lithium metasilicate (partially crystallized) with particle's size range between 0.2 m and 1 m . After crystallization the size of particle become 5m. The crystallization process accompanies the prismmatic glass ceramics formation and dispersed over the glassy matrix [28] . Furthermore, as the crystal spacing become more intense and the proportion of lithium disilicate microcrystals within the glassy matrix increases from 40% to 70% after complete crystallization, a 0.2% linear contraction occurs during crystallization process; this modification can increase marginal gaps [12] .

The differences between the systems was highly significant this agree with Att, Komine et al and Abduo , Lyons et al [35, 36] whom concluded that the use of different systems for fabricating zirconia frameworks has an effect on the final marginal and internal fit. The fabrication method (technique of scanning, process of milling , milling burs size and condition of material during milling procedure) can have an effect on the adaptability of ceramic restorations [29].

Imes - Icore CAD/CAM system (group A) provide less marginal gap as compared with In lab Sirona CAD/CAM , this could be because that the Imes - Icore CAD/CAM system has five axis milling machine while the In lab Sirona CAD/CAM has a four axis milling machine[12] . The addition of axes to the machine has improved the accuracy and precision of ceramic restorations , these two additional guide axes permit for machining and milling of difficult parts that cannot be milled with three or four axis milling device. The cutting conditions of 5-axis milling device are superior to those of three or four axis milling device, which provide restoration with excellent texture , dimensional accuracy and surface finish .This could illuminate the more appropriate marginal fit of the restoration made with a five axis milling device. [30].

This coincides with Hamza and Sherif [15] whom assessed the marginal gap of monolithic zirconia restoration fabricated on stainless steel die which scanned by one scanner and the crowns milled by different milling machine :MCXL milling machine (4axis) , Ceramil motion 2 milling machine(5axis), Wieland dental milling unit(5axis),Zirkonzahn milling unit M1(5axis), and VHFS1dental milling machine (5axis) ,the result showed that all tested CAD /CAM systems produce monolithic zirconia restoration with clinically acceptable marginal gap and CAM machines with 5axes produce lower marginal gap.

This is in contrast to the study done by Beuer , Korczynski et al [31] whom investigated the marginal and internal fit of zirconia based fixed dental prostheses fabricated by a Cercon eye laser scanner then the prostheses fabricated with the laboratory (3-axis) CAD/CAM system (Cercon brain) and the centralized CAD/CAM system Compartis Integrated systems (5- axis) they reported that there is no significant difference for both system with mean values (56.0± 34.5μm) and (51.7± 45.2μm), respectively, both means value are below than the clinically acceptable value (120μm).

And disagree with Al-Assadi and Al- Azzawi [18] whom assessed the effect of veneering of porcelian on the marginal gap of zirconia coping compared to full contour zirconia crown fabricated with Amman Girbach CAD/CAM system (5axis dry milling) ,Sirona CAD/CAM system (4axis wet milling) ,and Zikonzahn CAD/CAM system (5axis dry milling) . They measured the marginal gap by Stereo microscope. They reported that all mean values are below than the clinically acceptable value ,and the Sirona system produce the lower mean value.

The milling burs of these CAD/CAM systems vary in shape and these differences may affect the final result of ceramic prosthesis [32, 33].

Conclusion

In the light of the result obtained, the study concluded the following:

1 .Both CAD/CAM systems fabricated lithium disilicate crowns with clinically acceptable marginal gap mean value before and after crystallization.

2. marginal gap increased after crystallization due to ceramic contraction at the margin , which occur during densification of lithium disilicate crowns.

3. 5axes system showed statistically lower marginal gaps than the 4axes CAD/CAM system.

Conflict of interest: None.

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العنوان: تاثير عملية التبلورعلى فرق الحافات لتيجان الايماكس كاد باستخدام نوعين مختلفين من انظمة الكاد كام

الباحثون: فاطمة كاظم غدير , لطيف عيسى علوان, عبد الكريم جاسم العزاوي

المستخلص:

الخلفية: يعد التكيف الهامشي أمرًا بالغ الأهمية لتحقيق النجاح على المدى الطويل لترميم التاج والجسور. يكتسب نظام التصميم بمساعدة الكمبيوتر / التصنيع بمساعدة الكمبيوتر (CAD / CAM) أهمية أكبر في تصنيع ترميم الأسنان. الهدف : الهدف من هذه الدراسة هو تقييم تأثير عملية التبلور على فجوة الحافات العمودية للتيجان الخزف الزجاجي المصنعة بواسطة نظامين كاد /كام مختلفين.

المواد وطرق العمل: : تم تصنيع عشرين تاجًا من نوع الخزف الزجاجي . كان لدينا مجموعتان رئيسيتان (أ ، ب) (10 تيجان لكل مجموعة) وفقًا لنظام الكاد كام المستخدم: المجموعة أ: مصنعة بنظام كاد كام **Imes - Icor**e ؛ المجموعة ب: مصنعة بنظام كاد كام **In Lab Sirona**. وتنقسم كل مجموعة الى مجموعتين فرعيتين : تيجان الخزف الزجاجي قبل البلورة (أ 1, ب1) و تيجان الخزف الزجاجي المبلورة (أ2, ب2). لقد تم قياس فجوات الحافات لأربع علامات مؤشرة على كل وجه من اوجه النموذج المعدني .تم اجراء القياس بواسطة المجهر الرقمي بتكبير **(110X)** وبرنامج معالج الصور (**image J**) تم قياس العينات مرتين قبل وبعد عملية التبلور.

النتائج: اقل معدل فجوة الحافات قبل وبعد التبلور كان **(29.387±2.774μm)**و **(70.108±5.569μm)** على التوالي للمجموعة أ واعلى معدل فجوة الحافات قبل وبعد التبلور كـــــــان **(51.728 ±3.774μm)** و**(84.071 ±4.567 μm)** على التوالي للمجموعة ب. اختبار **Paired sample t-test** اظهر اختلافا احصائيا عاليا بين المجاميع قبل وبعد التبلور

الاستنتاج: ان عملية البلورة تزيد من فجوة الحافات . أظهر نظام **Imes - Icore** فجوة الحافات اقل من نظام **Sirona**. النظامان لهما فجوة حافات مقبولة.