

Marginal Discrepancy and Fracture Resistance of CAD/CAM Ceramill Sintron Metal Copings with Different Porcelain Materials

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ABSTRACT

Background: This study was performed to compare the marginal fit changes and fracture resistance of metal ceramic crowns constructed from Ceramill Sintron metal coping veneered with three different porcelain veneering materials (Vita Master Koromikos VMK, Willi Geller Creation CC and GC initial MC), also to evaluate the influence of thermocycling on load at fracture.

Materials and Methods: Master brass die was scanned, then metal coping was designed and milled from Ceramill Sintron blank to get 60 metal copings, then divided randomly into three groups (20 sample), then veneered with porcelain: VITA, Creation or GC. The marginal gaps were measured before and after porcelain veneering then marginal fit changes was calculated. Fracture resistance test was done by Instron®, the master die was duplicated to sixty analogs then each analog was fixed into acrylic base. After that each crown was cemented onto the corresponding die analog. Ten samples of each group were subjected to compressive loading to fracture and other ten subjected to thermocycling followed by compressive loading to fracture.

Result and Conclusion: The result of marginal fit changes showed that GC group had the lowest marginal gap followed by VITA and Creation. While VITA group showed the highest fracture resistance followed by GC then Creation. Thermocycling process did not significantly reduce the load at fracture for all groups.

Key words: Ceramill Sintron, Fracture resistance, Marginal gap, metal ceramic crown. (*J Bagh Coll Dentistry 2017; 29(2):7-12*)

INTRODUCTION

In the advent of the all-ceramic crown with its improved aesthetics and CAD/CAM technology which may considerably speed up the process of restoration delivery, the porcelain-fused-to-metal restoration still has superior fracture strength due to its rigid metal core ⁽¹⁾, and still considered as the gold standard because of their excellent biocompatibility, consistent esthetics, superior strength, and marginal adaptation ⁽²⁾.

Co-Cr for dental purposes was manufactured using three different production technologies: the lost wax technique, CAD/CAM milling and direct metal laser sintering ⁽³⁾.

One major advantage of using milling technology is that some disadvantages of casting, such as casting-induced flaws and porosities which can degrade the quality of the reconstructions, can be avoided as the blanks are manufactured under highly standardized industrial conditions ⁽⁴⁾.

A new chrome-cobalt material (Ceramill Sintron, Amann Girrbach) in combination with a new processing strategy now enables this alloy to be milled in the pre-inserted state quickly and cost-effectively using the subtractive technique.

Like the most widely established processing strategy for dental zirconia, the blanks also consist of a material in a preliminary state technically ⁽⁵⁾. Ceramill Sintron is relatively new introduction to construction metal coping for metal ceramic restoration. To date, No previous studies evaluated the effect of different porcelain veneering materials on marginal gap and fracture resistance of metal ceramic crown construction from Ceramill Sintron metal coping.

The aims of this in vitro study were:

1. To evaluate the influence of using three different veneering materials build up (Vita Master Koromikos, Willi Geller Creation CC and GC initial MC) on marginal fit changes of Ceramill Sintron metal copings.
2. To compare fracture resistance of different ceramic materials.
3. Study the effect of thermocycling on fracture resistance.

MATERIALS AND METHODS

Die preparation

A brass die model has the shape of central incisor was mounted to metal ring using dental stone to be stable during the preparation, and then the assembly was mounted to the base unit of the surveyor.

A dental surveyor was used for the preparation which was done by a high-speed turbine that was attached to the vertical arm of the surveyor with a specially designed cross-like pipe holder to keep

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the bur vertical to the finishing line and parallel to the longitudinal axis of the die Figure (1). The completed die was 7 mm in length from incisal edge to finishing line, the width was 5mm incisally and 6 mm gingivally and 8 degree of convergence, with chamfer finishing line all around with a depth of 1 mm.

Fabrication of the Copings

The prepared Brass die was removed from metal ring then mounted in base former using wax to hold the die in position during stone pouring, after the stone set, the stone base with die was removed from the base former and it was ready to be placed in CAD-CAM scanner.

Scanable powder was applied to the die to obtain precise scanning picture. Ceramill 3D InLab Software was used to design the coping with the following information, thickness of wall was 0.5mm, and thickness of cement gap was 25 micrometer, starting from 0 mm at the deep

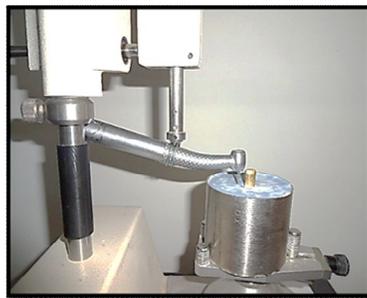


Figure 1: Die preparation.



Figure 2: Ceram bond



Measurement of the marginal discrepancy difference

Measurements were made for metal coping before and after porcelain veneering. Changes in the marginal fit of the coping after porcelain application were calculated for each coping. During measurement each metal coping and then finished metal ceramic crown had been seated on the Master metal die that was fixed to a clear acrylic block with parallel surfaces⁽⁶⁾.

A reference point was placed on each of four aspects of the base of the die below the margin of the preparation, as a mark. Measurements were made at the same point on each aspect. A "spring" loaded holding device⁽⁷⁾ was used during measurements figure (3).

Specimens were examined under a measuring light traveling microscope calibrated to 0.001 mm (1 μ m) at magnification X 100. The marginal

chamfer finishing line, vertical crown margin (metal collar) was 1 mm. Mounting the Ceramill Sintron® Co-Cr block to the Ceramill motion (Milling unit) for dry milling, after complete milling of the copings, the copings were removed from Ceramill Sintron® Co-Cr block using bur attach to laboratory engine. The green state metal copings had been sintered using Ceramill Therm (sintering furnace).

Sample Grouping:

Each group consisted of twenty metal copings (n=20), then veneered with porcelain: VITA for group A, Creation for group B and GC for group C.

Ceram bond® was applied to metal coping using brush, however, Ceram bond and all steps of ceramic build up must not cover the metal collar figure (2). The Porcelain application using layering technique, according to manufacturer instruction firing chart.

adaptation of each metal coping and finished metal ceramic crown were determined by measuring the vertical marginal discrepancy between the margin of the preparation and the gingival margin of the coping or crown^(7,8).



Figure 3: "Spring" loaded holding device

Fracture resistance test

I. Master Die was duplicated to sixty metal analogs :

The Master die was removed from the previous block and fixed to another large clear acrylic block. The die was duplicated using mold of the prepared master die that was made with polyvinylsiloxane putty impression material. The mold was used to make 60 wax patterns; later these wax patterns invested and caste, to get 60 die analogs.

II. Die analogs mounting in acrylic base:

A Base former coated with aluminum foil and place into table of surveyor, The die analog was fixed into a piece of sheet wax inside the base former , then adjustment for die analog position was done to ensure that its long axis was perpendicular to horizontal plane figure (4) .Cold cure acrylic was mixed then poured immediately to base former. After complete setting of cold cure acrylic, the base was taken off from base former, this procedure was repeated to get 60 die analogs in acrylic base.

III. Cementation of crown to die analog

Zinc phosphate cement was used for crown cementation, and it was mixed, then applied to the internal surface of the crowns. Finger pressure was applied to initially seat each crown on its respective die analog then remain under static pressure of 2.5 kg for 10 minutes using custom made device.

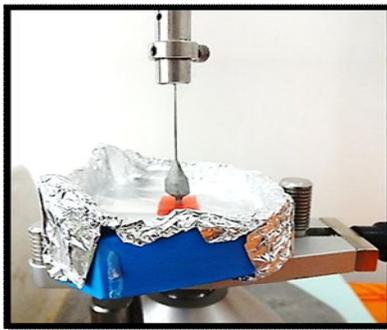


Figure 4: Die analogs mounting in acrylic base

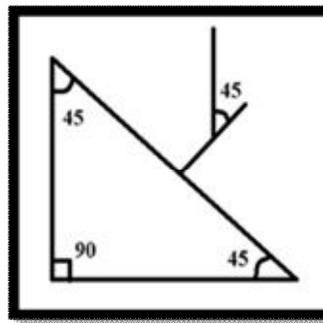


Figure 5: Angle of load application



Figure 6: Load application

IV. measurement of load at fracture:

Each group was randomly divided into two subgroups (10 crowns). The crowns of one subgroup was loaded in the Instron machine at an angle of 45 degrees to the long axis of the die analog-crown assembly using custom made table figure (5).

This angle of loading was chosen to simulate a contact angle between maxillary and mandibular anterior teeth found in Angle's Class I occlusal relationship⁽⁹⁾. A stainless steel rod with a 2-mm wide flat end, mounted on a universal testing machine (Instron), was used to apply controlled loads to the crown, at a crosshead speed of 2.5 mm/min, until fracture. The compressive load was applied palatally, 3 mm lower than the incisal edges of the specimens⁽¹⁰⁾ Fig (6). The load at fracture was recorded.

The crown of the other subgroup of the samples was subjected to thermocycling. The samples were submitted to 500 thermo-cycles in distilled water between 5°C and 55°C. The exposure to each bath was 30s and the transfer time was 10 second⁽¹¹⁾.

After thermocycling (aging), all samples were subjected to load until fracture using the same procedure that used for crowns that did not subjected to thermocycling. The maximum force to produce fracture was recorded in Newtons.

RESULTS

For marginal fit changes parameter the result of this study showed that the GC group have the lowest mean of marginal gap changes which was 5.5µm, while 6.1 µm for both VITA and Creation group (table-1).

ANOVA test showed that there is significant differences among group (table-2), while LSD test showed that there was a no significant difference between the VITA group and the Creation group ($P > 0.05$), also there was highly significant

difference for both comparison (Creation group vs. the GC group) and (GC group vs. VITA) group at $P < 0.01$ (table-3).

The result related to the effect of ceramic veneering material on the fracture resistance showed that the VITA group was have the highest mean of load at fracture which was 1127 N, followed by the mean of GC group which 825.3 N , and the lowest mean was 529.7 N for the Creation group (table-4).

Table 1: Descriptive statistics of marginal fit changes* (µm) of all groups

Group	N	Mean	S.D	Min.	Max.
VITA	20	6.1	0.731	5.0	7.3
Creation	20	6.1	0.599	5.0	7.0
GC	20	5.5	0.685	4.2	6.8

* Marginal fit changes = marginal gap after porcelain veneering – marginal gap before

Table 2: ANOVA test for mean marginal gaps among the groups

S.V.O.	S.S.	df	Ms	F	P-value	Sig.
Between groups	4.693	2	2.347	5.161	.009	HS
Within Groups	25.916	57	.455			
Total	30.609	59				

Table 3: LSD test for mean marginal gap changes between groups

Groups		P-value	Sig.
VITA	Creation	.870	NS
Creation	GC	.006	HS
GC	VITA	.009	HS

Table 4: Descriptive statistics of mean load at fracture (N) of all group: without aging and with thermal aging

	Subgroup	N	Mean	SD	Min.	Max.
VITA	Without aging	10	1127	146.57	870	1350
	With aging	10	1121.3	144.67	865	1330
Creation	Without aging	10	529.7	39.77	490	592
	With aging	10	525.2	38.1	489	600
GC	Without aging	10	825.3	126.93	580	1088
	With aging	10	821	122.68	610	1100

ANOVA test showed that there was high significant differences at $P < 0.01$ (table-5), while LSD test showed that there was a highly significant difference among all groups (VITA, Creation and GC group) $P < 0.01$ (table-6).

Result related to effect of thermocycling (aging) on the load at fracture of each group showed that the mean of load at fracture for VITA subgroups were 1127 N for without aging subgroup and 1121.3N for aging subgroup. Also

Creation subgroups mean were 529.7 N, 525.2 N for with aging and without aging respectively, while the mean of without aging subgroup of GC was 825.3 N and 821N for with aging subgroup (table-4). However Student's t-test show that aging (thermocycling) not significantly deteriorate the fracture resistance of subgroups independent on the type of porcelain veneering at $P > 0.05$ (table-7).

Table 5: ANOVA test for mean of load at fracture among the groups

	S.S.	df	M.S.	F	p-value	Sig.
Between Groups	1783898.467	2	891949.233	68.302	.000	HS
Within Groups	352592.200	27	13058.970			
Total	2136490.667	29				

Table 6: LSD test for the mean of load at fracture between groups

Groups		P-value	Sig.
VITA	Creation	.000	HS
Creation	GC	.000	HS
GC	VITA	.000	HS

Table 7: Comparison of load at fracture (N) between subgroup (no aging) and (with aging) of each group using student's t-test.

Comparison between subgroups	P-value	Sig.
VITA without – with aging	.931	NS
Creation without – with aging	.799	NS
GC without – with aging	.939	NS

DISCUSSION

Marginal gap value was measured for each metal coping before and after porcelain veneering in order to obtain marginal fit changes value⁽¹²⁾ to ensure that effect of metal coping manufacturing variable on marginal gap was excluded. The lowest mean of marginal fit changes values of coping was 5.5 μm for GC group, while the mean of changes of the other groups (VITA, Creation) was 6.1 μm . Statistical analysis showed a highly statistical significant difference in marginal fit changes when compare GC by VITA and GC by Creation, while there was no significant difference between VITA and Creation group.

There were no previous similar studies to compare with. However, Veneering process and its associated heat-treatment are known to affect the marginal fit of metal or ceramic core materials⁽¹³⁻¹⁵⁾. In present study, three different porcelain veneering materials were used with three different firing protocols. This may account for the difference in the mean of marginal fit changes between groups.

Another explanation was the thermal incompatibility between metal and veneering porcelain. However, this facts cannot interpret the result of this study because all types of porcelain veneering used had approximately the same CTE (25–500°C), in addition Ceram bond that was used in present study which acts as an efficient CTE buffer between porcelain and metal alloy⁽¹⁶⁾. Another factor that may cause marginal discrepancy was external grinding and internal abrasive blasting of crowns⁽¹⁷⁾.

Statistical analysis related to the result of fracture resistance showed that there was a highly significant difference among all groups (VITA, Creation and GC group) $P < 0.01$. The factors that lead to the fracture of metal-ceramic restorations can be classified into: technical factors, dentist-related factors, inherent material properties, direction, magnitude and frequency of applied loads, environmental factors. Technical factors include: surface treatment and design of the metal coping, compatibility between the coefficient of thermal expansion of the metal and Porcelain, ceramic build-up and firing technique, thickness of Porcelain, thickness and elastic modulus of the metal substructure and location of Porcelain-metal finish lines⁽¹⁸⁾.

In the present study, technical factors and applied load variables cannot explain the result of this study since all of these variables were excluded by standardization technique except the firing technique which differed among the groups which may affect the fracture resistance. Also dentist-related factors and environmental factors

were excluded since the study was in vitro not in vivo. Inherent material strength and different microstructure of porcelain can explain the result of present study since different types of porcelain veneering materials were used⁽¹⁹⁻²¹⁾ which had different grain sizes.

The statistical analysis result show that thermocycling (aging process) show no significant difference in fracture resistance in all group, this may be due to fewer thermocycling number. This agreed with Fiket *et al.*⁽²²⁾ and Makramani *et al.*,⁽¹¹⁾ while disagreed with Abou-Madina and Abdelaziz⁽²³⁾.

Within the limitation of this study, the following conclusions could be drawn:

1. GC group had significantly lower marginal fit changes among the tested groups.
2. There was no significant difference between VITA and Creation groups in marginal fit changes.
3. Fracture resistance was highest for VITA follow by that of GC then Creation.
4. Thermocycling did not significantly reduce the amount of force up to fracture of all groups.

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المستخلص

دقة الحواف والقوة، لأي ترميم معوض للأسنان هي صفة مهمة. ويمكن اعتبار عدم تطابق الحواف أو قلة القوة سبب مهم يؤدي إلى فشل التعويضات الأصبغاعية للأسنان. لذلك تم إجراء هذا البحث لغرض تقييم أختلاف ظبط حافات ومقاومة الكسر لتيجان السيراميك المصنعة من أغلفة ال Ceramill Sinton المعدنية مكسو بثلاث مواد خزفية مختلفة والتي هي (GC , Creation , VITA) ، إضافة إلى تقييم تأثير التدوير الحراري على قيمة الحمل المطلوب للكسر. طريقة العمل فقد تضمنت استعمال نموذج (Die) مصنوع من مادة البراص و يمثل القاطع العلوي الأمامي المحضر لتصنيع ستين غلاف معني بطريقة الخراطة باستخدام قالب ال Ceramill Sinton. ثم تم تقسيمها عشوائيا إلى ثلاث مجموعات ، كل مجموعة تتكون من عشرين غلafa وقد تم أكسابها بقشرة خزفية نوع VITA للمجموعة (أ) ، خزف نوع Creation للمجموعة (ب) و خزف نوع GC للمجموعة (ج). وقد تم قياس دقة الحواف قبل وبعد إضافة القشرة الخزفية لكل مجموعة باستخدام المجهر الضوئي المتنقل، لغرض حساب مقدار التغير في دقة الحواف. بعد ذلك تم اختبار مقاومة الكسر بواسطة جهاز ال Instron والطريقة كانت كالآتي : مضاعفة النموذج المحضر (Die) إلى ستين نظير ، ومن ثم كل نظير يثبت بقاعدة من ال(acrylic). بعد ذلك كل تاج سيراميك يثبت إلى نظيرها باستخدام الزنك فوسفيت سمنت. وقد تعرض عشرة من كل مجموعة إلى ضغط مستمر لغاية الكسر والعشرة الأخرين تعرضوا إلى عملية التدوير الحراري ومن ثم تعرضوا إلى ضغط مستمر لغاية الكسر.

أظهرت النتائج أن مجموعة التيجان المكسوة بخزف نوع GC كانت تختلف أختلاف واضح عن المجموعتين الأخرتين في قيمة تغير دقة الحواف ، في حين لا يوجد أختلاف واضح ما بين المجموعة المكسوة ب VITA و Creation. بينما كان هناك أختلافا جليا بين المجموعات بمقدار مقاومة الكسر، في حين أن عملية التدوير الحراري لم تقلل قيمة الحمل عند الكسر إلى حد كبير.

و يمكن أن نستنتج من هذه الدراسة : أن مجموعة التيجان المكسوة بخزف نوع GC قد أظهرت أقل تغيرا في دقة الحواف. في حين كانت مقاومة الكسر هي الأعلى للمجموعة VITA يليه مجموعة Creation ثم المجموعة GC. إضافة إلى ذلك عملية التدوير الحراري تقلل الحمل عند الكسر ولكن ليس إلى حد كبير .