Comparing Government (School) vs. Private (non-school) Dental Laboratories in Marginal Adaptation of Single Porcelain-Fused-to-Metal Crowns

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Abstract

Aim: The purpose of this study was to compare school and non-school dental laboratories in marginal adaptation of single Porcelain-Fused-to-Metal (PFM) crowns.

Method: Six dental laboratories (three school- and three non-school laboratories) participated in this study. Each dental laboratory was requested to fabricate PFM crowns for three different ivorine teeth on different typodont jaw models (n=18). The crowns received from the laboratories and fitted in their abutments using fit-checker under uniform pressure. We examined 162 sites viewed under a scanning electron microscope to measure the vertical and horizontal marginal discrepancy.

Results: The mean vertical marginal discrepancy for school dental laboratories was 208.9 µm, while for non-school dental laboratories was 182.8 µm. For the horizontal marginal discrepancy, the median values were 48.5 µm for school dental laboratories and 50 µm for non-school dental laboratories.

Conclusions: There was no statistically significant difference in the mean vertical and median horizontal values between school and non-school dental laboratories. However, a significant difference was observed within the non-school laboratories.

Key Words: Government, Private, Dental laboratories, Marginal adaptation, PFM crown, Scanning electron microscope

Introduction

Porcelain-Fused-to-Metal (PFM) crowns are still one of the indications for esthetic full coverage restoration. To produce a successful PFM crown, there are several requirements must be considered. These involve careful diagnosis of the case, preparation following the recommendations, good impression-taking, and working with good laboratory and a skilled technician who can reflect his skills on the work.

Marginal adaptation is one of the most important criteria for long-term success of PFM crowns. Significant marginal discrepancies expose luting material to oral environment, which leads to more aggressive rate of cement dissolution caused by oral fluids and chemo-mechanical forces. The cement seal then becomes weak and permits the percolation of bacteria which leads to caries development, periodontal diseases and subsequent failure of the prosthesis [1-4].

There are some variations in opinions regarding the value for clinically acceptable margin adaptation. Some previous studies reported value between 40 and 120 µm [5-9]. Other studies reported wider marginal discrepancy up to 180 µm [10-12]. There are several different factors may cause distortions of PFM restorations during fabrication process which lead to improper fitting of the restoration or marginal discrepancy. Some of these factors are related to the type of impression materials [13], other factors are related to distortion in porcelain and/or metal substructure [14-20]. Most distortion occurs during thermo cycling of the metal-ceramic alloy during the oxidation firing and surface finishing phase [21]. The type of alloy and margin design can also affect the accuracy of marginal adaptation [22,23]

In the literature, most studies rely on scientific laboratories under carefully controlled conditions to study marginal gap variation. However, most restorations cemented by dentists are fabricated by dental technicians working in dental laboratories where waxing, casting and porcelain firing are more difficult to control [24]. To create acceptable marginal adaptation, good facilities and skillful dental technicians are very important. Not all dental laboratories are able to afford good equipment's and high quality of material, in addition to hire skillful dental technicians, especially with governments dental schools where the treatment provided for free of charge and no income resource are provided to support their dental laboratories.

Aim

The purpose of this study was to investigate and compares the accuracy of marginal adaptation of single PFM crowns fabricated by dental laboratories of government dental school and private dental laboratories. The primary null hypothesis of this study was that the difference in the accuracy of the marginal adaptation between government and private dental laboratories is statistically significant.

Materials and Methods

Invitation letters were sent to 10 dental laboratories to participate in this study, six of them were agreed to join the study (three government dental schools laboratories, and three private dental laboratories). Approval for the study was received by Institutional review board of each dental school, and a consent form was signed by the director of each private dental laboratory.

Three sets of upper and lower typodont jaw models (dental model, NISSIN, Japan) with a complete set of upper and lower ivorine teeth (Melamen teeth, NISSIN,

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Japan) were used in this study. Three different teeth were prepared to receive a full coverage PFM crown. One tooth preparation was done for each model as follows: *Model number I:* Tooth preparation for upper left central incisor (tooth # 21).

Model number II: Tooth preparation for upper right first premolar (tooth # 14).

Model number III: Tooth preparation for upper left first molar (tooth # 26).

Teeth preparation

A standard set of diamond burs was used to achieve an acceptable preparation suitable for full-coverage PFM crown (DZ, Diamond burs, Germany). Teeth preparations for all teeth have been done by one prosthodontist (one of the authors). The preparation was designed with a 2 mm occlusal height reduction for the central incisor and functional cusps for the premolar and molar teeth, and 1.5 mm reduction for the non-functional cusps of the premolar and molar teeth. Buccal reduction was 1.2-1.5 mm with axial reduction of the proximal and lingual surfaces from 0.5- 0.7 mm. All finish lines were chamfer finish lines free of any irregularities.

Impressions taking and laboratory's instructions

Six individual (custom) trays for the working arch of each jaw model were fabricated using VLC auto polymerizing acrylic resin material (PRECI TRAY, YETTI Dental, Germany). All custom trays designed with 2 mm space between the tray and the typodont surfaces. A heavy body and light body vinyl polysiloxane impression materials were used to take the final impression for each prepared tooth (Virtual®, Ivoclar vivadent®, Italy). All impressions were taken by the Prosthodontist according to the manufacturer's instructions using light body material on and around the prepared tooth and heavy body material on the impression tray after applying a layer of tray adhesive (Universal tray adhesive, Zhermack®, Italy). After removal, all impressions were inspected for any defects or unclear margins using 2.5× magnification loops. Each impression was sent to each laboratory within 24 hours with a duplicated stone model of the opposing arch and vinyl polysiloxane bite registration (Virtual®, Ivoclar vivadent®, Italy).

Clear and unique instructions were given to each laboratory to "fabricate full coverage porcelain fused to metal crown with metal-supported porcelain on the facial margin for the prepared tooth, and complete finishing polishing and glazing to be ready for cementation". Same shade number was written on all laboratory request forms. Each laboratory was given one week from the date of submission the case to complete the required order.

Upon receiving the work from each laboratory, each restoration was examined carefully for deformity and debris using 2.5× magnification, and steam cleaner (TRITON SLA, BEGO®, Germany) wear used to clean the fitting surface of the crown.

Measurements of marginal crown/tooth junction

All specimens were viewed using a Scanning Electron Microscope SEM (JEOL GSM-6360LV) at 10 kV and 100X magnification. All measurements were obtained using SMile View software (Version 2.05 copyrights 1998-2000 JEOL LTD).

To carry out the measurements, each ivorine tooth was fitted in a pre-designed metal base (*Figure 1*). These metal bases were fabricated in an octagonal shape to facilitate the measurement of the marginal gap in eight pre-selected areas [Buccal (labial), Palatal, Mesial, Distal, Mesio-Buccal (Mesio-labial), Mesio-palatal, Disto-Buccal (Disto-labial) and Disto-palatal]. Each octagonal metal base was designed originally with wax-up in specific dimensions with two anti-rotational grooves (to prevent rotation of the tooth) and then casted to metal to ensure accurate fitting. To measure the gap from a reproducible point each time, a mark has been placed close to the margin on the tooth structure in the middle of each pre-selected areas.

The measurements of all crowns fabricated by the dental laboratories have been done blindly. Each PFM crown was fitted to the corresponded ivorine tooth using Fit checker (GC Japan, Inc-White). A 5-kg static load for 90 seconds was applied to the occlusal surfaces to allow adequate seating of the restorations. After complete setting of the fit checker, the margin was polished with rubber point (Porcelain adjustment kit, Shofu®, Japan) using a low-speed hand piece. One investigator made all the measurements. The crown/tooth junction was measured in two directions: Vertical (marginal gab) and Horizontal (overhang margin). To measure the overhang margin, one line was drawn through two selected points on the marginal side of the root (root line), and a perpendicular line was drawn pass through the margin of the crown (crown margin line). The overhang margin was calculated by measuring the distance on the "crown margin line" between the "root line" to the farthest point of the crown margin (*Figure 2*).

Data was analyzed using SPSS pc + version 21.0 statistical software. Descriptive statistics (mean, standard deviation, median and inter quartile range) were used to describe the quantitative symmetric and skewed study variable. Student's *t*-test for independent samples was used to compare the mean values between government (school) and private (non-school) dental laboratories, and one-way analysis of variance was used to compare the mean values among the three labs. For non-parametric data, the statistical tests: Mann-Whitney U-test was used to compare mean ranks skewed data between government and private laboratories, whereas the Kruskal Wallis test was used to compare the mean ranks of skewed

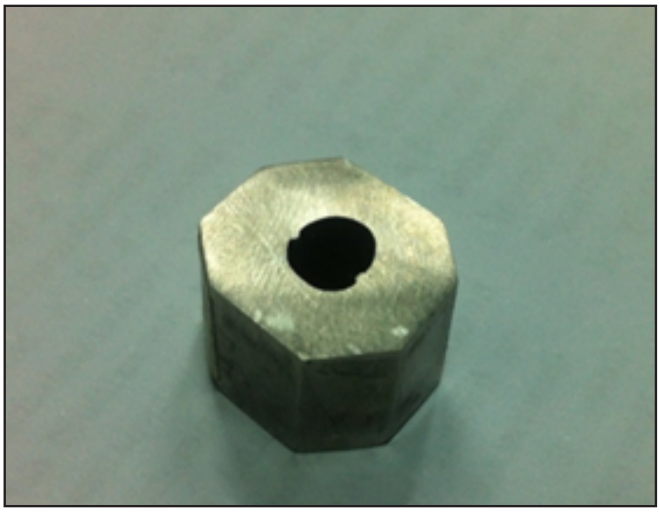

Figure 1: *The octagonal metal base used to facilitate the measurement of the marginal gap in 8 pre-selected areas.*

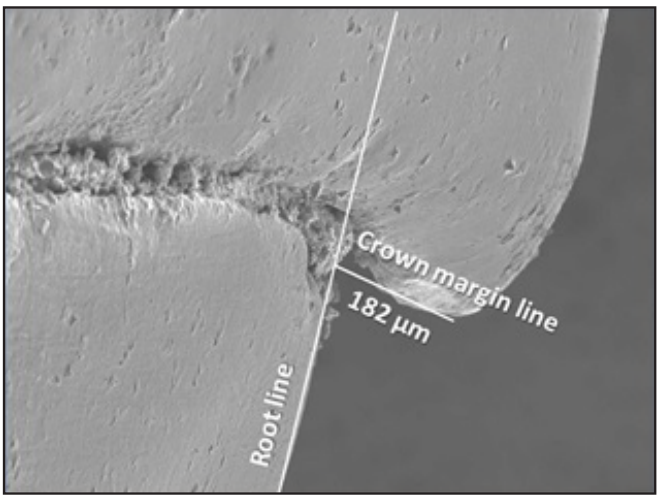

Figure 2. *Measurement of horizontal marginal discrepancy under scanning electron microscope.*

data among the three laboratories. A p-value of < 0.05 was used as statistically significant to infer the results.

Results

A total of 104 vertical and 64 horizontal marginal discrepancy values, for 16 PFM crowns, were measured in this study. Some 16 vertical and eight horizontal marginal discrepancy values for crowns #14 and #26 belonging to lab-3 of the school laboratories group were excluded during scanning measurement because of improper fitting of these two crowns.

Total mean values and SDs of the marginal discrepancy for all government and private laboratories were 193.87 µm (105.68 µm) for vertical discrepancy, and 79.63 µm (78.95 µm) for the horizontal discrepancy. The mean vertical marginal discrepancy for government dental laboratories was 208.9 µm, while for private dental laboratories this was 182.8 µm. For horizontal marginal discrepancy, the median value for government dental laboratories was 48.5 µm, and for private dental laboratories this was 50 µm (*Table 1*). There was no statistically significant difference between the mean vertical values and mean ranks of horizontal values of the government and private dental laboratories. However, there was a statistically significant difference in the mean vertical value of lab-3 of the private dental laboratory group. The mean vertical value for lab3 is statistically significantly lower than the other mean values of Lab1 and Lab2 in the private labs, and is also lower than those of the school dental labs. The mean and SD values for vertical and horizontal marginal discrepancy for each government and private dental laboratory are shown in *Table 2*.

When comparing the values for each tooth, there was no statistically significant difference between the mean vertical values and mean ranks of horizontal values of the government and private dental laboratories for the three teeth (*Table 3*).

Discussion

Marginal accuracy of full coverage restoration is an important criterion of quality of fixed prosthodontics [25]. An *in vitro* method to evaluate the marginal fit was selected in this study to have more control and accurate method to compare the marginal gap.

The magnitude of the marginal opening produced in this study may be considered high (193.87 µm), but is consistent with previous studies (40 – 150 µm) [5-12]. The type of metal alloy (base metal alloy) used to fabricate these crowns could be one of the factors for increasing marginal discrepancy [14]. Also, the different coefficients in thermal expansion between base metal alloys and the porcelain could be responsible for an increase of marginal gap [26]. Furthermore, the wide variation in the same tooth could be due to the inaccuracies in determining the finish line in the die trimming procedure. Evaluation of the marginal gap after crown cementation could be also one of the possible causes for increasing marginal discrepancy [27-30]. Beschnidt et al. found that measuring the gap after cementation might have more value than pre-cementation measurement [28]. In this study the silicon indicator paste (fit Checker) was used to fit the crown on the corresponded tooth, and it has been reported to be comparable to the regular cement such as Zinc phosphate in affecting marginal discrepancy [31]. Also, the seating pressure applied during cementation is close to the seating force that may applied clinically using finger pressure during try-in procedure (78.5 ± 12.8 N) [32]. However, the possible difference in seating finger pressure did not result in a significantly different marginal gap.

Both government and private dental laboratories had almost similar results in the average marginal opening. All dental laboratories in this study were using base metal alloy, and facilities and equipments available in each laboratory were similar. This could be one of the reasons for the non-significant result of vertical and horizontal marginal discrepancy. However, two crowns fabricated by one of the government dental laboratories did not fit, and measurement could not be completed because of improper fitting. This outcome may significantly affect our result, it may be considered as a strong indication that government (school) laboratories are limited in producing acceptable crowns. More investigation is needed to find the reason for improper fitting. However, it is more related to the quality control in government labs.

The sample of this study was limited to three laboratories of school and non-school, and three crowns for each laboratory, which is a rather small sample from which to draw robust conclusions. However, this may considered as an exploratory study and findings of this indicate the pattern of the problem and it gives scope to generate hypothesis to be tested in future studies. Also, controlling the accuracy and smoothening cut of the finish line during marginal preparation may control the variation in measurement and give more accurate reading using SEM.

Conclusion

The total value of the vertical marginal discrepancy in this study was higher than previous studies (193.87 µm). In general, there was no statistically significant difference between government and private dental laboratories in vertical and horizontal marginal discrepancy. However, there is a strong indication that government (school) laboratories are limited in producing acceptable crowns because of improper fitting of two crowns. Further studies with more samples of the crown restorations and dental laboratories are required.

Table 1. *Comparison of mean vertical and mean ranks of horizontal values between government and private laboratories.*

Type of marginal discrepancy	Type of labs		t-value/Mann-Whitney U-value	p-value
	Government lab	Private lab		
Vertical	208.9 ± 100.8*	182.8 ± 108.6*	1.24	0.22
Horizontal	48.5 (61)**	50 (97)**	443.5	0.41

*Mean ± sd; ** Median (IQR)

Table 2*. Comparing vertical and horizontal value for marginal discrepancy of all teeth among the three Government and private dental laboratories.*

Type of Laboratories	Type of marginal discrepancy	Laboratory Number			F-value	P-Value
		Lab-1	Lab-2	Lab-3		
Government Labs	Vertical	204.4 (82.4)	197.6 (121.3)	287.5 (14.9)	1.38	0.26
	Horizontal	76.7 (61.7)	53.5 (44.3)	57.5 (13.3)	0.67	0.52
Private Labs	Vertical	205.6 (116.6)	212.5 (110.8)	130.4 (79.9)	3.8	0.027
	Horizontal (median & IQR)	75 (94)	37.5 (105)	44 (91)	-----	0.44*

* = Krushkal-wallis test

Table 3*. Comparison of mean (ranks) of vertical and horizontal values of the three teeth among government and private dental laboratories.*

Tooth Number	Type of marginal discrepancy	Type of Labs mean (SD)		t-value/ Mann-Whitney U-test value	p-value
		Government Labs	Private labs		
14	Vertical mean (SD)	155.7 (72.4)	187.8 (102)	-1.16*	0.25
	Horizontal Median(IQR)	36 (54)	58 (104)	29.0+	0.14
21	Vertical mean (SD)	301.4 (76.6)	199.7 (139.1)	2.20*	0.04
	Horizontal Median(IQR)	56 (42)	44 (112)	70.5+	0.93
26	Vertical mean (SD)	192.6 (97.1)	169.4 (101.2)	0.72*	0.48
	Horizontal Median(IQR)	62.5 (74)	49 (75)	47.0+	0.97

* = t-value

+ = Mann-Whitney U-test value

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