Evaluation of marginal adaptation of ceramic crowns depending on the marginal design and the addition of ceramic

Edson Hilgert[1]
Leonardo Buso[1]
Maximiliano Piero Neisser[2]
Marco Antonio Bottino[2]

[1] *MDS, Graduate student, Department of Dental Materials and Prosthodontics. Faculdade de Odontologia de São José dos Campos – UNESP, SP, Brazil.*

[2] *DDS, MDS, Professor, Department of Dental Materials and Prosthodontics. Faculdade de Odontologia de São José dos Campos – UNESP, SP, Brazil.*

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Correspondence to:
Edson Hilgert
Rua Francisco Paes, 31, apto. 22
Centro - São José dos Campos
CEP 12210-100 São Paulo Brazil
Phone: +055 012 39227621
E-mail:ehilgert@yahoo.com

Abstract

This study evaluates the marginal adaptation of ceramic copings front of two finish lines and addition of ceramic. Hence, two master steel dies were milled with all-ceramic crowns preparation, one with a round shoulder finish line margin design, and the other with a deep chamfer. From each one of them, 15 *copings* were made, and the marginal discrepancy was evaluated in measuring microscope. The ceramic addition was accomplished in both groups with aid of a silicone matrix, and the discrepancies were measured again, obtaining the final mean gap values. The initial measurements resulted means of 44,0μm for deep chamfer and 24,0μm for the round shoulder, and the final measurements were 53,3μm for the deep chamfer and 27,4μm for the round shoulder. The data were submitted to the analysis of variance for verification of influence of the finish lines and application of the ceramic. When analyzed the interaction among the variables it was not observed statistical differences, but when comparing the two types of finish lines or the groups before and after ceramic addition, statistical differences were found. It is was concluded that the round shoulder finish line presents better values of marginal gap than deep chamfer and the addition of ceramic influences in the final gap values of marginal adaptation.

Key Words:
dental ceramics, marginal adaptation, finish lines

Introduction

The development of ceramic system of improved strength and esthetics has broadened the use of metal-free restorations for anterior and posterior regions

However, the longevity of fixed prosthodontics depends on the quality of the marginal adaptation to the abutment teeth. Marginal gaps can create a favorable condition for biofilm deposition, thereby contributing to the development of caries and periodontal disease[1-2]. Moreover, regardless the type of cement, large gaps increase the wear of the cement regardless its type[3]. The In-Ceram Alumina (Vita-Zahnfabrik) is a ceramic system designed for manufacturing metal-free indirect restorations. The material contains particles of alumina incorporated and sintered in a first firing to form a porous sub-structure, which is infiltrated later by liquefied lanthanum glass on a second firing cycle. The low sintering shrinkage and porosity given by the combination of these two processes is responsible for the good adaptation and high strength of the material[4-7]. The type of the finish line is one of the factors that influence the marginal adaptation of crowns. For metal-free crowns, the two predominant types of finish lines suggested by the literature are the round shoulder and the deep chamfer[7-8], with the bevel being contraindicated for ceramic restorations. Some authors have pointed out the importance to evaluate the effect of the finish line on the marginal gap of all-ceramic crows[6,8-10]. Other factors besides the finish line also influence the fidelity of the marginal adaptation of prosthetic crowns, for example the addition of the covering ceramic. The stability of the copings as a function of the firing procedures has been evaluated in the literature, for both metal-ceramic[11] and metal-free restorations[6,8,12-13]. Marginal distortion of metal ceramic restoration during various stages of fabrication is well documented. The authors are unaware of any study that has been conducted to examine the effect of porcelain application on the marginal discrepancy of all-ceramic restorations.

This way, the purpose of this study was to evaluate the influence of the finish line and the addition of the covering ceramic on the marginal adaptation of glass infiltrated alumina crowns.

Material and Methods

The metallic dies used in this study were milled in stainless steel with average dimensions of an inferior second molar. The milling simulated a preparation for a total metal-free crown, with two types of finish line: round shoulder and deep chamfer (Figure 1). A semicircular notch was machined in the cervical edge to allow replacing the crowns on the dies for the measurements. The experimental groups were divided according to the types of finish lines and the presence of the covering ceramic (Table 1).

Plaster replicas (Durone, Dentsply) were obtained from the metallic dies using the double impression technique with an addition silicone (Elite H-D, Zhermack, Italy) of two consistencies (putty soft and regular body) and normal setting. All impressions were taken in a standardized way using an adapted dental surveyor. The metallic die was fixed on a thread at the vertical rod, while a cylindrical tray was fixed at the base of the surveyor parallel to the axis of the vertical rod. The molding and the plaster material were manipulated according to the manufacturers' recommendations. The molds and the plaster dies were analyzed for the presence of defects and, in case any, the procedure was repeated. For each preparation type, fifteen impressions were taken, with a total of thirty molds and models obtained Then, the plaster dies were duplicated using a die spacer and a special plaster of the In-Ceram system. From these dies, the ceramic copings (In-Ceram system, Vita-Zahnfabrik, Bad Säckingen, Germany) were then constructed.

For the initial measurements, the metallic die was fixed to an octagonal base that served as orientation for the reading points. The coping was fixed in the metallic die with the aid of a device that applied a constant pressure at the measurement.

The measurements were carried out according to the marginal gap definition of Holmes et al.[14] (perpendicular measurement from the margin of the casting to the axial wall of the

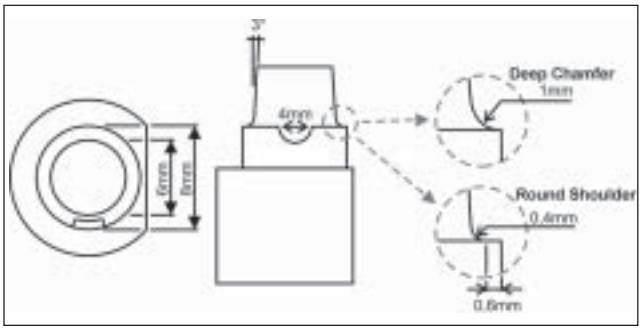

Fig. 1 – *Schematic drawing of the metallic master dies*

Table 1 – Division of experimental groups and results.

Ceramic addition	Finish lines					
	Round Shoulder (n=15)	mean		Deep Chamfer (n=15)	mean	
Before	R1	24,08 ± 9,37µm	A	D1	44,01 ± 12,64µm	A
After	R2	27,42 ± 11,87µm	A	D2	53,31 ± 15,24µm	A

preparation) using a measuring microscope (Olympus Microscope Precision STM, Tokio, Japan) with a digital table, 30X magnification and precision of 0.5ìm. Four diametrical opposing points had been chosen in the samples for the readings of the marginal gap. In each one of the points, three measurements had been carried through. With the 12 accomplished measurements, a initial mean marginal gap measure was obtained for the deep chamfer (D1) and rounded shoulder (R1).

After the initial measurements of the samples, the covering ceramic was added (Vitadur Alfa, Vita Zahnfabrik) with the aid of a silicone index. For such, a crown of an inferior molar was waxed over one coping, and the same positioned on the metallic die. The assembled pieces were then duplicated in addition silicone. The matrix was then positioned over the other copings attached to the metallic die, and the ceramic was applied through an oclusal opening of the matrix, occupying the space of the wax.

For the first firing of the ceramic a layer of dentine and enamel was applied and fired in Vita Vacumat 40 furnace (Vita Zahnfabrik, Bad Säckingen, Germany), according to manufacturer's recommendations. A second firing cycle for correction was carried out, followed by a third cycle for glazing using Akz25 (Vita Zahnfabrik). The parameters of the firing protocol are described in Table 2. The samples were measured again and the values after ceramic covering obtained (D2 and R2).

The data of the initial and final measurements were submitted to a two-way ANOVA at a confidence level of 95%.

Results and Discussion

Data of marginal gap distances for deep chamfer and rounded shoulder are presented in Table 1.

The factors finish line and ceramic addition were detected as sources of variance ($p<0.05$), while the interactions between these factors not ($p>0.05$) (Table 3).

Table 2 – Firing cycles of the ceramic.

	Program number	Temperature
Enamel and dentin layer	22	960°C
First correction	23	950°C
Glaze Akzent Akz25	26	920°C

Nowadays, it is unquestionable the importance of the development of ceramic materials in substitution to the prostheses with conventional metallic infrastructure. When applied in selected cases, these materials present some positive aspects, in what it concerns to the biocompatibility and extremely favorable aesthetics[15]. On the other hand, the functional aspect of the restoring systems has to be evaluated from way to provide safety in the clinical use of these materials. This way, the evaluation of the marginal adaptation of ceramic crowns is of extreme importance for the scientific proof of clinical situations, once the precision of adaptation among the substitute material to the lost dental structure and the tooth is directly related to the longevity of the prosthesis.

In this work, we evaluated the marginal adaptation of In-Ceram crowns, in function of the finish lines of the preparations, before and after the firing of the covering ceramic. In the literature, some works verify the influence of the finish lines of the preparations used for metal free crowns[6,8-10], being observed the indication of horizontal configuration finish lines, especially the round shoulder and deep chamfer, once the bevel is contraindicated in this prosthesis type, because thin margins tend to fracture with easiness in ceramic restorations. Shearer et al.[8] used two methods of evaluation. One a direct sectioning technique and the other a cement analogue using a addition-cured polyvinyl siloxane impression material. No significant difference in fit was found between chamfer margins and shoulder margins (mean=19µm) and addition of ceramic to In-Ceram copings and repeated firing cycles did not alter the fit. Sorensen[9] introduced a measuring method where crown samples were embedded on master dies and embedded for sectioning buccolingually and mesiodistally. Photographs of margins with plastic overlays indicating emergency profiles were used to determine vertical and horizontal marginal discrepancies. Hoard et al.[10] compared the marginal fit of full coverage crowns with 3 marginal configurations (chamfer, shoulder and 45° shoulder). The crowns were cemented on the original working dies and embedded in clear casting resin. Specimens were sectioned mesio-distally and facio-lingually, and photographed at 120x magnification. A plastic overlay was superimposed on the photographs. The median margin discrepancies were 111µm for 45° shoulder,

Table 3 – Results of the test of analysis of variance (ANOVA) (p=0.05)

	Summary of all Effects					
	dfEffect	MSEffect	dfError	MSError	F	p-level
Finish Line	1	7873.479	28	196.4924	40.07015	**7.56E-07**
Ceramic	1	599.136	28	114.1153	5.25027	**0.029673**
Fin. Line x Ceramic	1	132.9677	28	114.1153	1.165205	0.2896

90µm for the chamfer and 83µm for the shoulder. Values of marginal adaptation were observed before the application of ceramic, in 44,01 ± 12,64µm for deep chamfer and of 24,08 ± 9,37µm for the round shoulder, and after application of ceramic of 53,31 ± 15,24µm and 27,42 ± 11,87µm, respectively. It was observed that an influence of the finish lines exists in the marginal adaptation of the crowns, being observed better results with the round shoulder front to the deep chamfer. We believed that this better adaptation is credited to a greater operational easiness by a larger volume in the margins. Besides it, the sharper borders, proportionate for the deep chamfer, can be more easily damaged in finishing or sandblasting.

An important point in the technical aspect of the confection of these crowns is related to the verification of the stability of the infrastructure in function of the several firings of the covering ceramic. For this, the measurements were accomplished before and after the ceramic addition, being that three ceramics burnings had been carried through - two for build up of dentin and one for glazing. In our studies significant differences were found when compared the values before and after the addition of covering ceramic. This difference can be attributed among the stages of the procedure to some factors, firstly to a possible alteration of the infrastructure in alumina. In the literature, some studies disagree with our findings, observing stability of these infrastructures[6,8,12-13]. Shearer et al.[8] used Vita Alpha porcelain to establish a typical full crown form, using three firing cycles which was considered a typical number for a clinical case. Sulaiman et al.[13] (1997) made the measurements after the fabrication of the core material, after dentin and enamel porcelain applications and after glazing. Groten et al.[12] evaluated the marginal fit of copy milled In-Ceram crowns after different stages of fabrication steps. For veneering, three firings were performed to complete the crowns. Vitadur Alpha ceramic was used and the inner surfaces were sandblasted at a reduced pressure 1.5 bar to remove all possible all possible remains of veneering ceramics. None of the authors mentioned a matrix for standardization of the thickness of ceramics, as it was made in our study. An explanation for the lack of agreement is the variation in the method used by various investigators in studying marginal discrepancy. However, other factors can be listed, mainly in relation to the contamination of the internal surface and of the margins of the coping in function of the ceramic addition. Studies related with adaptation of metal-ceramic crowns show that mismatches proceeding not from the distortion of the infrastructure exists, in function of the ceramic contamination in the internal surfaces of the copings, injuring the sitting of the prosthesis[11,16]. In this study, there was not internal adjustment of the prosthesis for the accomplishment of the second measurements, of form this factor could infuse in alterations in the sitting.

Nevertheless, the values observed so much before, as after the aesthetic covering, are located in a range of values between 24,08 ± 9,37µm to 53,31 ± 15,24µm in the analyzed groups. It is observed in the literature several works that esteem the values of width of marginal gap considered as clinically acceptable, but not arriving to a consent, turning this a controversial parameter and difficult to comparing. These values locate in a range that initiates in 39µm[17], passing by 50µm[6]; 50 to 74µm[18]; 70µm[19] up to 120µm[20]. In any way, all the values found in this study are inside of this range, giving us larger safety for the clinical use of these restorations.

In this study artificial model-patterns were used in substitution to you natural teeth, due to the proportionate benefits of experimental models similar to the clinical situation. Natural teeth present great variation due to the age, it individual structures and time of storage, making it difficult the standardization of the pillars. For that, several authors have employee metallic or resin models for measurement of the marginal fidelity[6,8,12-13] with some advantages, as few present variables, easy reproduction and obtaining, besides all the samples always starts in the same initial situation.

To the measurements of marginal adaptation, in our study, were accomplished without cementing the crowns. This choice was made, uniform with several studies in the literature[12-13], where it is believed that when cementing them, the precision of primary adaptation is lost, and the influence of the cement type, viscosity and luting techniques become preponderant. We believed that the cementation should not be used to compare systems for confection of crowns or situations that influence the precision of primary adaptation of these restorations.

Thus, with the limitations of this study, we noticed that the influence of the aesthetic covering ceramic seems not to be enough great to make with that the adaptation of the crowns leaves of a range of clinical acceptance. It is observed although that a well-known difference exists in function of the cervical end, being that better results were reached for the round shoulder design.

Starting from the used methodology and of the obtained results, it is observed that, when analyzed the groups in function of the interaction finish lines x porcelain, statistical differences does not exist among the same ones. However, when analyzed the factors separately, influence in such a way of the finish lines types was observed, being that the round shoulder presented better marginal adaptation, as of the application of the aesthetic covering ceramic, where its negative influence in the gap values was observed. Still thus, despite the joined statistical differences, the marginal adaptation values found in this study are inside of the acceptable clinical parameters observed in literature, making to assume that these parameters are not disturbing when transposed to the clinical reality.

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