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The Ability of Dental Specialists to Distinguish Lateral Incisor Metal-Free From Porcelain-Fused-to-Metal Implant Supported Crowns

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Abstract - *The objective of this study was to evaluate the ability of dental specialists to distinguish lateral incisor metal-free from porcelain-fused-to-metal implant supported crowns in the anterior region. Five single-tooth implants in the maxillary lateral incisor region were restored with two types of implant-supported crowns (porcelain-fused-to-metal and metal-free). Photographs were presented to 20 evaluators. The evaluators had to answer whether the crown was: metal-free, porcelain-fused-to-metal or they could not tell the difference. The results showed that groups 1 (all participants), 3 (Restorative & Prosthodontic specialists), 4 (graduated ≤ 10 years) and 5 (graduated > 10 years) failed to respond correctly (P > 0.05) to which type of crown was presented to them. Group 2 (Periodontology & Implantology specialists) showed an accuracy rate of 35.6% (P = 0.009), in relation to metal-free crowns,5.6 which is below the random index. The authors concluded that the evaluators from the 5 groups studied were unable to significantly distinguish which type of crown was used in the 10 presented situations.*

KEY WORDS: dental implants, perception, crown, blinded clinical trial.

INTRODUCTION

Currently, single-tooth implant treatment success is no longer defined only by its survival rate but also by the aesthetic parameters, especially in the aesthetic zone.[1] Both the dentist and the patient expect results similar to the aesthetics of the natural dentition.[2] The maintenance of the soft and hard tissue architecture and an imperceptible integration of the final prosthesis with the host tissues are, nowadays, imperative for treatment success.[3]

To date, titanium abutments could be considered the "gold standard" in regards to biocompatibility of the material, and prosthetic stability and biological longevity when used in all sites of the jaws.[4-5] However, the pursuit for an imperceptible prosthesis leads to the use of metal-free restorations in preference to the porcelain fused-to-metal (PFM). The PFM crowns do not allow for a satisfactory esthetic result when placing a highly translucent prosthesis due to the metal abutment reflecting light in a greyish hue through the gingival tissues in addition to blocking the light reflecting throughout the prosthesis.[6] Thus, ceramic abutments were developed in an effort to solve this problem, improving the transmission of light and mimicking the optical properties of a sound natural tooth.[7-8]

Clinical studies have demonstrated considerable success rates in implant supported reconstructions with titanium abutments.[9] Likewise, implant supported reconstructions with zirconia abutments show low rates of biological and/or prosthetic complications.[10-11] When comparing titanium and zirconia abutments, both showed no statistically significant differences when analyzing biological complications, abutment fracture, prosthetic fracture, or screw loosening.[12-14] These data can be confirmed by systematic literature reviews, making it impossible to point to the superiority of one treatment over another.[12,15] Schwarz *et al.*[14] observed a statistically significant higher trend for metal-free prostheses to show crown chipping when compared to PFM prostheses. This can be a result of thick layers of porcelain on abutments or copings with low thermal diffusivity, such as a zirconia, are prone to generate high tensile subsurface residual stresses which may result in unstable cracking or chipping.[17] Perhaps, one of the main reasons to choose a metal-free prosthesis could be to avoid the greyish colouration that a metallic abutment could cause in the peri-implant mucosa close to the cervical aspect of the crown. The peri-implant mucosa contains fewer blood vessels when compared to the gingiva and it has been shown that the vasculature has an influence on the gingival colour.[18-19] Thus, this may be a reason for the colour variation that occurs between the peri-implant mucosa and the gingiva.[12-13,20-21] Importantly, the peri-implant mucosa is usually thicker than the gingiva, with averages ranging from 1.9 mm to 3.4 mm of thickness.[12-13,20] Studies *in vitro*[22] and *in vivo*[23] determined that the human eye cannot perceive changes in the colour of the peri-implant mucosa when it is thicker than 2mm, using either titanium or ceramic abutments. Therefore, the peri-implant mucosa colour change caused either by the titanium or zirconia abutments were similar, not reaching statistically significant differences.[12-13,2] Only one study compared the use of implant supported metal-free and PFM prostheses from the dentist's perception.[24] In this study, the perception of the evaluators failed

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to distinguish when it was a metal-free or a PFM prosthesis, raising doubts about the true influence of the abutment used in the final aesthetic result of an implant supported prosthesis. Even though the methodology of this study involved intra-oral photographic evaluations which have certain limitations, Luo *et al.*[25] has indicated this to be a valid evaluation method.

The present study aimed to evaluate the ability of dental specialists from different fields to distinguish between metal-free or PFM crowns used to restore single-tooth implants in maxillary lateral incisors.

MATERIALS AND METHODS

Study design

The study was approved by the Ethics Committee for Research involving Humans at the Federal University of Santa Catarina. Three patients were invited to participate in this research, giving a total of five implants placed in the maxillary lateral incisor region. All five implants had an external hexagonal prosthetic platform with a 3.3 mm diameter (Master Porous, Conexão Sistema de Prótese, São Paulo, Brazil) and had been placed in the ideal position (cingulum) of the lost original tooth. All patients were informed about the characteristics of the study and signed an informed consent to participate. Patients were evaluated and it was verified that all were in accordance with the inclusion criteria for this study.

Inclusion criteria were:

- Age > 18 years.
- Absence of periodontal disease.
- A single implant with an external hexagonal platform, placed in a lateral incisor site of the maxilla.
- Presence of an acrylic resin provisional crown screwed directly onto the implant for at least 3 months with a screw access hole in the cingulum of the provisional crown.
- Presence of intact adjacent teeth or with minor composite resin restorations.
- Keratinized gingival width of at least 1 mm on the buccal aspect of the implant.

Exclusion criteria were:

- Heavy smokers (> 10 cigarettes / day).
- Presence of endodontic or periodontal lesions on the adjacent teeth.
- Failure during osseointegration.

Prosthodontic procedures

On each single implant, two screw retained single crowns were manufactured, one being a metal-free and the other a PFM. The final impressions were made at the implant level using a condensation silicone (ZetaPlus and Oranwash L, Zhermack, Italy) utilizing a closed tray implant transfer (057080, Conexão Sistema de Prótese, São Paulo, Brazil). The cast was made with a special type IV plaster (Fugirock EP, GC, Japan) and a polyether (Impregum Soft Light Body, 3m ESPE, USA) was used around the implants to condition the patient's gingival tissues into an esthetic profile. Afterwards, the casts were sent to a prosthetic laboratory to manufacture the final crowns.

For metal-free crowns, zirconia abutments were made from zirconia blocks (Zirkonzhan ICE, Zirconia Prettau 1 Alto, 22mm of height, Zirkonzahn Srl, Italy). The zirconia blocks were reduced to the desired shape leaving an average thickness of 1.5mm for the ceramic application (Fig. 1). The Vita VM9 system (Vita Zahnfabrik, Germany) was afterwards used in a stratified fashion to mimic the volumetric composition and the shade of a natural tooth.

For the PFM crowns, a metallic cast structure was manufactured from a cobalt-chromium UCLA abutment (056085, Conexão Sistema de Prótese, São Paulo, Brazil). The shape of the desired metal structure was waxed on the UCLA abutment, inserted into a mold for casting, and later fused with a cobalt-chromium alloy (Fig. 1). For finishing of the PFM crowns, a thickness of approximately 1.5mm to 2mm was left for application of ceramics. The EX3 Noritake (Noritake Dental Supply co., Japan) system was used also in a stratified fashion to mimic the volumetric composition and the shade of a natural tooth.

Abutment and crown try-ins were conducted for all final crowns in both groups until all the crowns reached satisfactory esthetics for the patients and the dentist, thus finalizing the laboratory procedures.

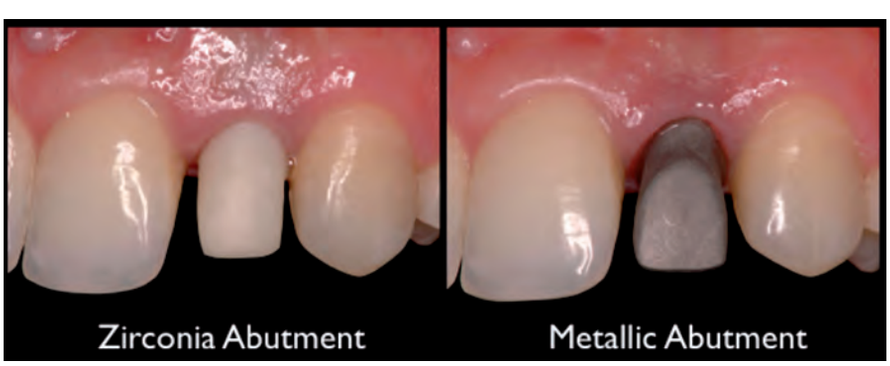


Figure 1. *Abutment try-in after fabrication over the same implant in tooth #10. Left: zirconia abutment. Right: metallic abutment.*

Collection of images

During the same clinical procedure, intra-oral photographs of the metal-free and PFM crowns were taken using a Finepix S2 Pro (Fujifilm Inc., USA) digital camera with a Medical 120mm Nikkor lens and a flash (Nikon Inc., USA). In this procedure, the provisional crown was removed and, randomly, the metal-free or PFM crown was placed and screwed directly over the implant. After placement of the final crown, the dental team waited five minutes for the gingival tissues to adapt to the crown, avoiding the blanching on the peri-implant mucosa, prior to taking the photographs. The photographs were standardized with the same camera settings. The flash intensity was 1/4, shutter speed 1/125 and aperture f/32. This step was made in order to reduce possible changes in the outcome between the photographs taken of the different patients.

In order to facilitate comparisons of the aesthetic results obtained, the adjacent teeth were also included in this photograph. One photograph out of all the ones taken of each crown (metal-free and PFM), was selected by the author, based on; its environment, cleanliness and focus. A total of ten images were selected, five for the metal-free group and five for the PFM group (Fig. 2). The selection made by one evaluator was to eliminate possible optical differences in colour, shade & texture between the participating dentists. The five implants selected from three patients showed to have ideal image position, size, shape, colour and similar gingival hue for the provider making the selection. The small number of implants and crowns used in this study were to obtain most results form different professionals without increasing the number of groups to be evaluated and the time necessary for this evaluation, considering all participants were active dentists and that the objective of the study was to have the most responses regarding only two different types of crown.

Figure 2. *Presentation of 10 selected photographs. Left: metal-free crowns. Right: porcelain-fused-to-metal (PFM) crowns.*

Data Collection

Forty dentists were invited to participate in this study. All participants were specialists and/or teachers and/or doctors in Periodontology, implant dentistry, restorative dentistry or dental prosthodontics. These participants were active in their field and were invited to take part in the study by means of a letter explaining the study's objective and the time required for their participation. The participants signed a consent form, which included details of the objectives and methodology of the study. In the first data collection visit, the participants informed their specialty field and the number of years since they had graduated in dentistry. All participants (Group 1) were further divided into 4 subsets according to area of expertise and time lapse since graduation:

- Group 1: All participants (n=40);
- Group 2: specialists with principal area of practice in Periodontology and Implantology (n=20);
- Group 3: specialists with main area of practice in Restorative Dentistry and Prosthodontics (n=20);
- Group 4: Participants graduated in dentistry ≤ 10 years (n=20); and,
- Group 5: Participants graduated in dentistry > 10 years (n=20);

Table 1. Qualitative analysis of participant's perception regarding the type of prosthesis that was presented (don't know, metal-free or PFM).

Image
What kind of prosthesis Mr. (s) believed to have:
(0) Don't know (1) Metal-free (2) Porcelain-fused-to-metal

A presentation was assembled using the Keynote software (Apple co., USA) and data collection was carried out individually using a MacBook Pro 15" (Apple co., USA) for the images presentation. These images were presented in a full screen in approximately 7 x magnification of the lateral incisors, thus facilitating the perception of details by the study participants.

A questionnaire was attached to the presentation, where the participants would answer the questions asked by the researcher.

Qualitative Analysis

The ten selected images of the metal-free and PFM crowns were presented randomly. Each participant had thirty seconds to answer the same question for each image (Table 1). The objective was to analyse the participant's perception of the type of crown that was presented as being: 1) don't know; 2) metal free; or 3) PFM. This was done successively until the end of the 10 images.

Statistical Analysis

Statistical analysis was performed by comparing the test by means of simple proportion (1.1 QuickStat Arcus, Cambridge, UK), comparing the percentage of correct answers obtained by each group to the percentage expected by chance according to the law of probability in this case of 50%. If correct answers are above the random index, it indicates that the event did not happen at random. It the correct answers were below the random index, it indicates that the event happened at random and that the correct answer is not statistically significant. The study sample was 5 patients that received 2 different types of crowns that were analyzed by 40 evaluators (n=400).

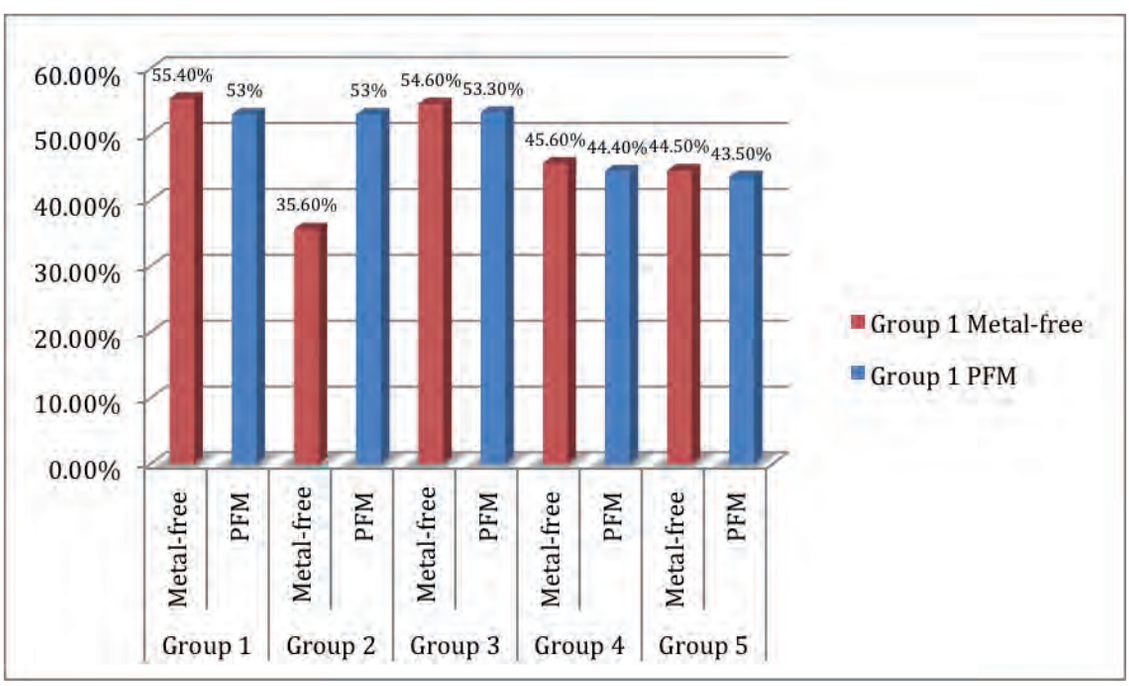
RESULTS

The qualitative analysis results from the participants in relation to the answers and the success rate regarding the observed images are shown in Table 2.

Table 2. Accuracy rate of the analyzed images from each participant divided into the 5 groups.

Groups	*Total images assessed*	*Answers (quantity)*			*Correct answers*		*P value*
		Type	*Qty*	*%*	*Qty*	*%*	
Group 1	400	MF	166	41.5	92	55.4	0.18
		PFM	168	42	89	53	0.48
Group 2	200	MF	87	43.5	31	35.6	0.009
		PFM	70	35	39	55.7	0.55
Group 3	200	MF	86	43	47	54.6	0.45
		PFM	92	46	49	53.3	0.60
Group 4	200	MF	79	39.5	36	45.6	0.49
		PFM	81	40.5	36	44.4	0.37
Group 5	200	MF	89	44.5	45	50.6	1.00
		PFM	87	43.5	34	39.1	0.053

P-values = 0.05 (statistically significant values are in bold).
PFM = Porcelain-fused-to-metal
MF = Metal-free



Graph 1. *Percentages of correct answers for each type of crown within each of the 5 groups.*

In Group 1 (all participants), 40 participants analyzed 10 images each (a total of 400 responses). Of this total, 66 (15.5%) responses were marked as "don't know", demonstrating that, in these images, participants were unable to identify which type of crown was present. In 166 (41.5%) responses, the participants answered that they were metal-free crowns, however, in only 92 (55.4%) responses they were correct in this statement, reaching a $P = 0.18$. As for the PFM crowns, 168 (42%) responses stated that this was the treatment option, being that 89 (53%) of these responses were correct in this statement ($P = 0.48$). Some evaluators answered, "I don't know" to the study question. The percentages of "I don't know" responses in each group were: 1, 66 (15.5%); 2, 37 (21.5%); 3, 22(11%) and 4, 40 (20%). These results indicate that the overall percentage of correct responses did not differ from random for both metal-free as well as for PFM crowns.

In Group 2 (Specialists in Periodontology and Implantology), 20 participants analyzed 10 images each (a total of 200 responses). The " don't know" alternative was marked in 43 (21.5%) of the 200 responses. In 87 (43.5%) responses, the participants answered that they were metal-free crowns and only 31 (35.6%) of the time they were correct ($P = 0.009$). When it comes to PFM crowns, this response was chosen 70 (35%) times, of which 39 (55.7%) times was correct ($P = 0.55$). These results indicate that this group of experts was unable to distinguish PFM crowns from random, but their choice of metal-free crowns proved to be wrong, because the accuracy was less than random.

In Group 3 (Specialists in Prosthodontics and Restorative Dentistry), from a total of 200 responses, 22 (11%) of them failed to identify which type of crown it was. In 86 (43.5%) responses, the "metal-free" option was marked but it was correct 47 (54.6%) times ($P = 0.45$). In 92 (53.3%) responses, the participants believed that the images were of PFM crowns, but only 49 (53.3%) were correct ($P = 0.60$). The results of these groups were similar to that seen on group 1, with no statistical difference.

There were also 20 participants in Group 4 (Graduated in dentistry ≤ 10 years) who analyzed 10 images each (a total of 200 responses). In 40 (20%) of theses responses, the participants were unable to distinguish which type of crown was present, while 79 (39 5%) participants chose a metal-free crown. Of these 79 responses, only 36 (45.6%) were correct ($P = 0.49$), while the participants believed that they were PFM crowns in 81 (40.5%) times, and they were correct in 36 (44.4%) ($P = 0.37$).

Group 5 (Graduated in dentistry > 10 years), had a total 200 responses. The participants could not answer what type of crown was present in 24 (12%) of the responses. They believed it was a metal-free crown n 89 (44.5%) times, which was correct 45 (50.6%) times ($P = 1.00$). When dealing with PFM crowns, 87 (43.5%) responses marked PFM as the treatment option, and they were correct in their choice in only 34 times (39.1%) ($P = 0.053$). In this group, the metal-free crowns diagnosis was similar to random and the PFM crowns diagnosis was lower than random.

DISCUSSION

Based on this study's initial hypothesis, the results demonstrated the inability of dental specialists, in general, to detect if the patient received metal-free or PFM prosthesis. Relating the response of all respondents, there was an accuracy rate for the metal-free crowns and PFM of 55.4% ($P = 0.18$) and 53% ($P = 0.48$), respectively, and those results indicate that the accuracy of the participants remained in a random range.

Even when dividing the groups in specialty and in period of time lapsed since graduation, in all groups studied, the accuracy for distinguishing metal-free from PFM ranged from 45-55%. This result also indicates a random pattern in the choice of response by the study participants, not reaching a statistically significant level. Our present findings concur with the ones of the study recently published in Gallucci *et al.*[24], where 20 implant supported crowns in the anterior maxilla (10 metal-free and 10 PFM crowns) were assessed by 9 dentists, and the accuracy level was of 50% and 47% for PFM and metal-free crowns, respectively. This study did not include general practicioners aiming at reaching a level of dental practitioners with a higher degree and years of formal education.

In our study, only group 2 (composed of Periodontology and implantodontists) showed a statistically significant index for the metal-free crowns accuracy rate (P = 0.009). However, the accuracy rate of this group was only 35.6%, indicating that this group had a lower accuracy level to random pattern. This means that there was no differentiation in better understanding the type of treatment used in this study, indicating that the correct answer could have been at random and therefore, is not statistically significant. The same can be said for group 5 (graduated in dentistry > 10 years), where a statistically significant rate (P = 0.053) was nearly reached for the PFM crowns, but also, with accuracy rate lower than the standard random (39.1% accuracy rate).

Ultimately, one of the major reasons to choose a metal-free prosthesis over a PFM would be the use of a ceramic abutment, avoiding the greyish colouration of the peri-implant mucosa which can be present when using a metallic abutment.[21] However, participants in this study were not able to distinguish in a statistically significant manner, which type of prosthesis was used in each procedure. These data are consistent with the findings from other studies,[13,15,22] where it was proven that a change in colour at the edge of the peri-implant mucosa exists, but this change is similar for both metallic and ceramic abutments, with this colour change not reaching statistical significance.

The authors suggest that, since the implants selected for this study were placed in a nearly ideal position, where the retaining screw had its access on the cingulum site of the prosthesis, the technician in dental prostheses was able to use a broad thickness of porcelain (around 1.5 to 2 mm), being able to mask the metallic structure, obtaining similar aesthetic results between the PFM and the metal-free prostheses. Apico-coronally, the position of the implants were 3 mm below the CEJ of the adjacent teeth. The mesial-distal position of the implants were within 1.5 mm of the adjacent teeth. The margin of the PFM crown was approximatel 1-2mm below the gingival sulcus. Therefore the study participants were unable to tell which type of prosthesis was used in each patient, with the level of accuracy being at a random level. Perhaps different results would have been found if the implants had been placed in less ideal positions where a smaller thickness of porcelain would have been used, resulting in a greyish hue of the gingival tissues surrounding a PFM prostheses, as indicated earlier by Nakamura *et al.*[6] The authors suggest the use of ceramic abutments in anterior cases where the implants are not ideally positioned, as indicated by O'Boyle *et al.*,[8] aiming at bringing optical properties of the ceramic abut-

ments that are similar to a healthy tooth. The different types of ceramics used were to better serve the individual differences of each patient's aesthetic needs.

Among the limitations of this study, the small sample size (10 implant supported prostheses) should be considered, however, the total of 40 participants raised this sample to 400 responses, which increased the statistical significance of the study. Another limitation was the use of intra-oral photographs for this evaluation. Even knowing the difficulty of reproducing two intra-oral photographs at different times, mainly due to camera angulation and flash direction, this model has been proposed by various studies and their results proved to be a valid method for this type of evaluation.[25]

The authors conclude that the participants selected for this study, regardless of their main area of expertise or time lapse since they had graduated in dentistry, were unable to distinguish in a statistically significant manner if the 10 samples from 5 implants of 3 patients were metal-free or PFM crowns, thus proving the hypothesis that the PFM crowns or metal-free are indistinguishable to the human eye in the situations proposed by the methodology of this study, which included implants positioned 3-dimensionally and therefore could be screw-retained. This allowed technicians to use 1-5-2mm of veneering porcelain in all cases and hence perhaps why the greyish gingival hue associated with PFMs was not a significant factor in this study.

DISCLOSURE

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