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Zirconia Abutment Supporting All Ceramic Crowns in the Esthetic Zone: Interim Results of a Prospective Study

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ABSTRACT

Aim: This prospective study evaluated peri-implant tissues around all-ceramic crowns fabricated using CAD/CAM technology. Material and methods: Twenty-five patients received pre-fabricated zirconia implant abutments with CAD/CAM zirconia copings in the esthetic zone. Implants were evaluated at baseline, and at 3 and 6 months in function. Results: Radiographic analyzes showed stable bone crest around the implants. Esthetics were more favorable as time lapsed (p>0.05). Bleeding Index was constant in all time intervals. Plaque index reduced from 3 to 6 months. Conclusion: The all-ceramic CAD/CAM crowns were clinically, radiographically and esthetically stable during the study period.

INTRODUCTION

The success of dental implant supported prostheses cannot be limited to osseointegration. An optimal esthetic outcome, which may be especially challenging in the anterior maxilla, should also be considered as part of the successful outcome. Ceramic restorations with unsatisfactory shade and shape, poor emergence profile, loss or distortion of the interproximal papillae, and exposure of the metallic implant components are the most common causes for compromised esthetic outcomes.[1, 2]

Titanium (Ti) abutments show biocompatibility and adequate mechanical properties.[2] The correct selection of a Ti abutment, and its customization allows the development of a restoration with acceptable emergence profile and esthetics. However, a disadvantage of using these types of rehabilitations for anterior sites is when the patient has a thin biotype,[3-5] leaving a grayish hue to the cervical tissues of the implant crown due to the abutment's metallic shade, blocking the diffusion and reflection of light.[6] Zirconia pre-fabricated abutments (ZrO_2) have shown to be useful in the esthetic zone. In addition, they've been useful as posterior abutments to substitute premolars and molars due to its resistance and positive impact on the health of the peri-implant tissues.[7-9]

The development of computer aided design/computer aided manufacturing (CAD/CAM) facilitated the fabrication of esthetic prostheses and customization of abutments, crowns and copings. CAD/CAM technology enables the use of materials that could not be used in dentistry otherwise.[10]

Few CAD/CAM coping and prefabricated zirconia abutment prospective studies are reported in the literature. The aim of this study was to evaluate clinically the peri-implant tissues and crowns over abutments prefabricated in ZrO_2 with coping fabricated with the same material using CAD/CAM technology.

MATERIALS AND METHODS

SUBJECTS

This study protocol was approved by the Research Ethics Committee for clinical studies of the Federal University of Juiz de Fora (approval number 156/2010). Fourteen consecutive patients (14 women and 11 men) with indication for implant therapy in 25 sites were included in this study. The patients were informed of the purpose of the study, the clinical procedures and the materials to be used. All the patients signed a consent form prior to their enrollment in this clinical trial. The inclusion criteria for the patients were: need for single-unit implant-supported crowns in the esthetic zone (from right maxillary second premolar to left maxillary second premolar), absence of systemic diseases, satisfactory oral hygiene, and no signs of bruxism. Smokers, patients presenting systemic diseases and patients in need for bone grafts were excluded from this study.

SURGICAL PROCEDURES

All regular platform external-hexed implants (Conexão prothetic Systems, Arujá, São Paulo, Brazil) were placed *(Table 1)* according to a two-stage conventional protocol.[11] Second stage surgery (abutment connection) was performed four to six months after implant placement.

PROSTHETIC PROCEDURES

A final transfer of the implant position was performed by means of an impression with polyether material using an open-tray technique and inclusion of a screwed transfer abutment. A tissue cast was created. The casts were mounted in a semi-adjustable articulator and the abutment type was selected according to the implant axis and the level of soft tissue. Nearly all abutments had to be individualized in the occlusal aspect and along the chamfer. During this process, special care was taken to reduce the wall thickness of the ZrO2 ceramic in the cervical region as little as possible. The ceramic was prepared with turbine and diamond-grinding tools under a water-cooling system.[8]

The ZnO_2 coping was fabricated using a milling process of the CAD/CAM subtractive wear system called System Precision (Conexão Sistemas de Prótese, Arujá, São Paulo, Brazil). Low temperature sintering nanofluorapatite glass-ceramics were applied on the copings, obtaining all-ceramic crowns. All the crowns were cemented with self-adhesive universal resin cement (Unicem Rely-XTM, 3M ESPE, Sumaré, São Paulo, Brazil). After crown delivery, the patients were evaluated at baseline, and after 3 and 5 months *(Figures 1-5)*. The evaluation included the following criteria: implant clinical success[12] *(Table 2)*, plaque index[13] *(Table 3)* and Mombelli's bleeding index (MBI)13 *(Table 4)*, Pink Esthetic Score (PES)/ White Esthetic Score (WES) *(Table 5)* and evaluation of the peri-implant tissues, by means of measuring the length of the peri-implant tissues from the implant platform to the gingival margin.[14,15]

Table 1. All mplants placed evaluated in this study.

Site	Implant diameter (mm) x length (mm)
Mx Right lateral Incisor	3.3 x 13
Mx Right lateral Incisor	3.3 x 11.5
Mx Right first premolar	4.0 x 10
Mx Right first premolar	3.75 x 10
Mx Right first premolar	3.75 x 10
Mx Right first premolar	3.75 x 10
Mx Right first premolar	3.75 x 10
Mx Right second premolar	3.75 x 13
Mx Right second premolar	4 x 8.5
Mx Right second premolar	3.75 x 10
Mx Right second premolar	3.75 x 10
Mx Right second premolar	4 x 8.5
Mx Left central incisor	3.3 x 10
Mx Right first premolar	4 x 10
Mx Right first premolar	3.75 x 13
Mx Right first premolar	4 x 8.5
Mx Right first premolar	4 x 8.5
Mx Right second premolar	3.75 x 11.5
Mx Right second premolar	3.75 x 11.5
Mx Right second premolar	3.75 x 11.5
Mx Right second premolar	4 x 11.5
Mx Right second premolar	3.75 x 11.5
Md Right first premolar	3.75 x 11.5
Md Right first premolar	3.75 x 11.5
Md Right second premolar	3.75 x 11.5

Table 2. Technical evaluation of the implants by clinical success criterion

Score	Clinical Success
1	Absence of persistent subjective complaints, such as: pain, foreign body sensation, and/or paresthesia.
2	Absence of recurrent peri-implant infection with suppuration
3	Absence of mobility

Source: Buser et al[14]

Table 3. Biological evaluation of the plaque Index

Score	Clinical Success
0	Absence of plaque deposits
1	Plaque visible only after slipping the tube over the free surface of the implant marginal gingiva
2	Clinically visible plaque
3	Abundant plaque

Source: Mombelli et al[15]

Table 4. Biological evaluation of the sulcus bleeding index

Score	Clinical Success
0	No bleeding when the tip of the periodontal probe is passed along the gingival margin linked to the implant
1	Bleeding isolated visible points
2	Bleeding forms a confluent red line in the margin
3	Heavy bleeding or profuse

Source: Mombelli et al.[15]

Table 5. Parameters for obtaining PES

Parameter	Absent	Incomplete	Complete
Mesial papilla	0	1	2
Distal papilla	0	1	2
	Major Discrepancy	Minor Discrepancy	No Discrepancy
Curvature of facial mucosa	0	1	2
Level of facial mucosa	0	1	2
Root convexity/ soft tissue /color and texture	0	1	2
Maximum total PES		10	

Source: Belser et al[16]

Table 6. Parameters for obtaining WES

Parameter	Major Discrepancy	Minor Discrepancy	No Discrepancy
Tooth form	0	1	2
Tooth volume/ outline	0	1	2
Color (hue/ value)	0	1	2
Surface texture	0	1	2
Translucency	0	1	2
Maximum total WES		10	

Source: Belser et al[16]

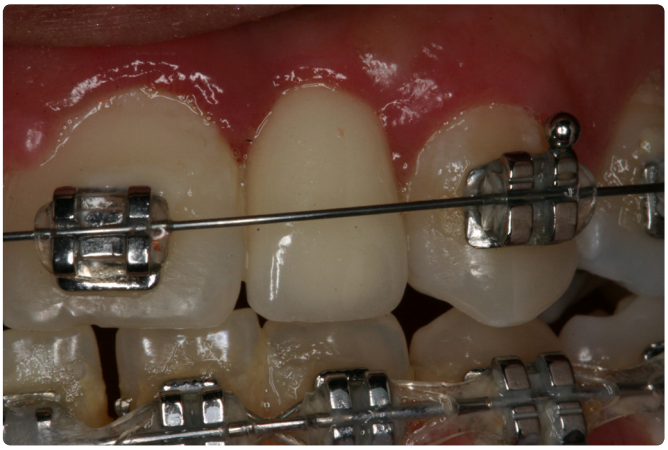

Figure 1: All-ceramic implant-retained nanofluorapatite glass-ceramic crown for maxillary left incisor

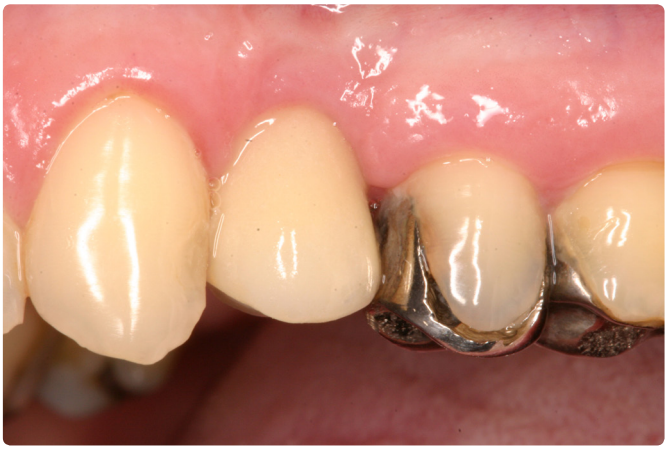

Figure 2: All-ceramic implant-retained nanofluorapatite glass-ceramic crown for maxillary left first premolar

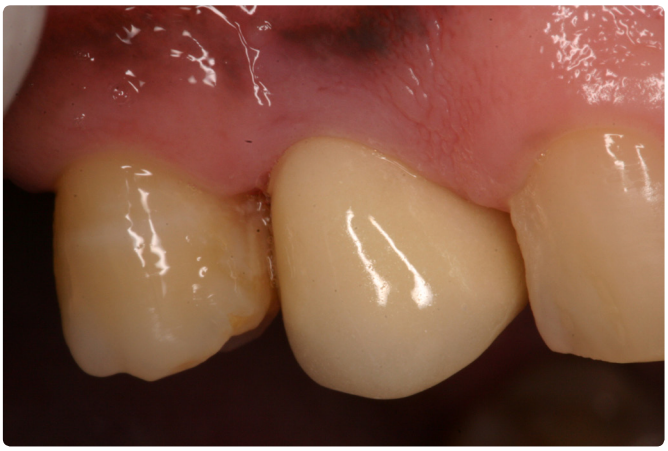

Figure 3: All-ceramic implant-retained nanofluorapatite glass-ceramic crown for maxillary right first premolar

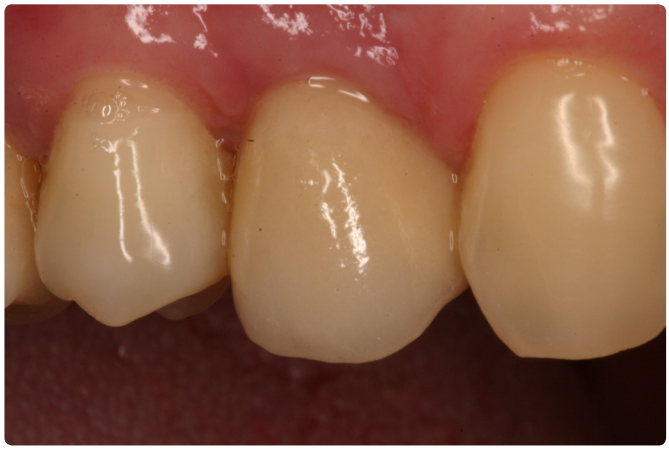

Figure 4: All-ceramic implant-retained nanofluorapatite glass-ceramic crown for maxillary right canine

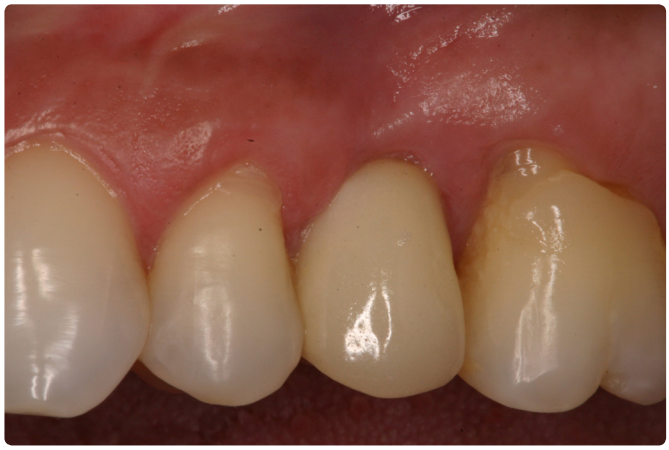

Figure 5: All-ceramic implant-retained nanofluorapatite glass-ceramic crown maxillary left second premolar

STATISTICAL ANALYSIS

For each time interval, the Mann-Whitney test was applied for the Mombelli,[13] Belser[16] and Blanes[14,15,17] scores. Friedmans' test was used to compare the three time-intervals with the Belser 1616 scores. Wilcoxon's test was used to compare the different time intervals with the Mombelli[13] and Blanes,[14,15,17] variables.

RESULTS

A total of 25 implant-supported crowns were delivered to 25 patients (14 women, average age was 43 years; and 11 men, average age was 33 years). Implant osseointegration was verified at the second surgical stage by means of manual torque test. After crown delivery, all implants were deemed successful using a predefined success criteria.[12] There was no prosthetic complication during the observation time of this study.

Patients in this study maintained satisfactory oral hygiene and displayed low Mombelli's plaque Index (PI) and Mobelli's bleeding Index (BI). No significant differences were registered for mucosal BI and PI at the 3 and 5-month follow-up appointments (Wilcoxon test, P = .059) *(Table 7)*.

The probing depth averages (V, MV, DV, P ou L, MP, DP) in Table 8 do not show statistically significant differences in the 3 and 5 month time intervals evaluated. There was no statistically significant difference in the evaluation of pink esthetics score *(Tables 9, 10 and 11*) in the different time intervals. The mean total PES scores in each time interval increased with as time lapsed. The peri-implant tissues remained clinically stable.

Friedman's test was applied in the "mesial papilla", "distal papilla" and convexity/shade/texture" PES categories. The mean values did not show statistically significant differences. While comparing the "buccal curve" mean scores in the time interval of this study, there was a statistically significant difference (P = .000) (Graph 1). Wilcoxon's test was used for the different time intervals (baseline, 3 and 5 months after crown delivery) comparisons; there were statistically significant differences (P = .001). However, the comparison between 3 and 5 months after crowns were in function, showed no statistically significant differences (P = .414) (Graph 1).

When the mean scores for the PES "buccal height" category were compared in the different time intervals, there were statistically significant differences (P = .042) (*Graph 2*). Wilcoxon's test was applied to compare baseline with the 3-month time intervals after crown delivery; there was no statistically significant difference (P = .083). When comparing 3 with 5-months after delivery, PES showed statistically significant difference (P = .025) (*Graph 2*). In the mean score comparisons of "total" PES in the different time intervals, there were statistically significant differences (P = .005), unlike the comparison between 3 and 5 months after the crowns were in function (P = .107) (*Graph 3*). The WES score was evaluated only at baseline, due to this evaluation being of inert material *(Table 13*). The mean "total" WES value was 8.36 (± 1.22) *(Table 14*), which was still above the clinically acceptable adjusted level, demonstrating that the ZrO_2 offers a favorable substrate for the esthetic zones (*Graph 4*).

Table 7. MPI and MBI mean scores

Scores	Mean values		P value
	3 Months	6 months	
MPI	0.36 (± 0.70)	0.16 (± 0,47)	0.059
MBI	0.56 (± 0.59)	0.48 (± 0,77)	0.593

MPI = plaque index; MBI = bleeding index

Table 8. Mean values in the survey sites

Site (mm)	Means		P value
	3 Months	5 Months	
V	3.16 (± 1.46)	3.00 (± 1.09)	0.463
MV	4.92 (± 1.52)	4.48 (± 1.51)	0.791
DV	4.76 (± 1.64)	5.20 (± 1.32)	0.107
P ou L	4.36 (± 1.25)	4.48 (± 1.19)	0.632
MP	5.20 (± 1.55)	4.92 (± 1.26)	0.106
DP	5.40 (± 1.29)	5.48 (± 1.23)	0.816

V: Buccal. MV: mesiobuccal. DV: distobuccal. P or L: palatal or lingual. MP: mesiopalatal. DP: distopalatal

Table 9. PES and their mean values immediately (baseline) after crown delivery

Means	Categories				
	Mesial Papilla	Distal Papilla	Buccal Curvature	Buccal Height	Convexity, color and texture
	1.08 (± 0.75)	1.20 (± 0.81)	1.00 (± 0.50)	1.64 (± 0.64)	1.04 (± 0.45)

Table 10. PES and their mean values 3 months after crown delivery

MEANS	Categories				
	Mesial Papilla	Distal Papilla	Bucal Curvature	Buccal Height	Convexity, color and texture
	1.20 (± 0.87)	1.32 (± 0.75)	1.60 (± 0.58)	1.76 (± 0.43)	1.12 (± 0.44)

Table 11. PES and their means 5 months after installation of the crown

MEAN Values	Categories				
	Mesial Papilla	Distal Papilla	Bucal Curvature	Buccal Height	Convexity, color and texture
	1.20 (± 0.82)	1.28 (± 0.79)	1.52 (± 0.50)	1.52 (± 0.50)	1.04 (± 0.35)

Table 12. PES total and mean values at baseline, 3 and 5 months after crown delivery and total PES for the study

MEANS	Categories			
	PES total immediately	PES total 3 months	PES total 5 months	PES throughout the entire study
	5.96 (± 1.72)	6.96 (± 0.64)	6.60 (± 1.91)	6.50 (± 1.76)

Table 13. WES and their respective mean values

Means	Categories				
	Form	Volume	Color	Texture	Translucency
	1.68 (± 0.47)	1.76 (± 0.44)	1.12 (± 0.48)*	1.24 (± 0.43)	1.76 (± 0.43)*

*(P = .000).

Table 14. WES total

Mean Wes Total
8.36 (± 1.22)

DISCUSSION

This was a prospective interventional study, which evaluated esthetic outcomes of tissues and crowns in 25 implanted sites. The survival rate for the crowns was of 100%. These results concur with the literature when analyzes were made after 5-years [17, 1-9, 18] and 3-years.[18]

The peri-implant tissues presented healthy without inflammation. In addition to the function[19, 20] and esthetic[8, 9, 17] benefits, the use of ceramic abutments can also minimize inflammatory processes and favor epithelial attachment.[9, 20] The present study concurs with the literature, which shows no statistical significant difference in the mean values of probing depths during the evaluated period of time.[21] There was reduction in the BI as time lapsed and a tendency to reduction of the PI around implants crowns with ZrO_2 abutments. A histological study[22] in humans showed that the ZrO_2 abutment caused less soft tissue inflammation when compared with the Ti abutments after 6 months of healing. This difference could have been due to the material, or its superficial topography which is more favorable to circumferential connective tissue and epithelial cell insertion[23] or due to the reduced ability to adhere bacterial plaque in the surface of the ceramic.[20, 23]

The esthetic outcomes were assessed with the PES/WES index proposed by Belser.[16] The mean PES score of 6.96 was lower than the mean obtained by other studies 24-26 but still above the threshold of clinical acceptance set at "6" by Belser.[16] The results of the present study could have been attributed to the treatment protocol used, where provisional crowns were not used prior to the final crown.[21]

The WES was only evaluated immediately after crown delivery, since it is inert material. The 6 months follow-up showed esthetic outcomes that were clinically acceptable, adjusted to the pre-established parameters (PES/WES), with a mean "total" WES of 8.36 (± 1.22). These results were more satisfactory than the mean WES of "7"obtained by Furze[25] and Belser,[16] who reached a WES of 6.9 with 20% of the crown below the score of "6". Other authors[9] showed a mean PES and WES of 9.03, a total mean of 8.15 in 3 years. Of the 55 crowns analyzed,[9] none showed a score below.[6] There were no statistically significant differences between all-ceramic crowns and porcelain-fused-to-metal crowns compared to ceramic abutments.

It could be speculated that the difference between the mean scores of the studied groups is related to the use of pre-fabricated ZrO_2 abutments with CAD/CAM copings, which resulted in superior esthetic benefits. A study indicated that[27] the CAD/CAM system shows the best passive seating, observed at the micrometer level. These studies, the ZrO_2 abutments received copings made of the same material, fabricated using a milling process of the CAD/CAM subtractive wear system, called System Precision (Conexão Sistemas de Prótese, Arujá, São Paulo, Brazil), which provides superior internal and marginal seating.[28] The crown fabrication was made by application of low temperature sintering nanofluorapatite glass-ceramics.

The physical properties of ZrO_2 allow individualization of the abutment by means of milling, respecting the minimum widths for the ZrO_2 copings.[10, 23, 29] The current study used pre-fabricated ZrO_2 abutments and individualized copings using the CAD/CAM system of the same material.

Knowledge of the wear process between dental implants and the ZrO_2 abutments are needed in order to provide better understanding of the interactions that occur at this interface between different types of materials. In addition, the presence of humidity can increase or reduce the wear quantity in comparison to the dry test. The long-term clinical effects are screw loosening and abutment fracture.[30] In the present study these effects were not evaluated. A previous study [23] showed that that ZrO2 abutments function up to 4 years without mechanical intercurrences. In the present study, radiographic and biological measurements were stable, indicating stability of the peri-implant tissues during the studied time interval. This study concurs with the literature,[31, 32] which shows that there was no statistically significant difference between the bone levels of both studied types of rehabilitations.

CONCLUSION

Satisfactory clinical and radiographic results were shown in this preliminary short-term study. Long-term evaluations are necessary before definitive clinical recommendations are made on the use of ZrO_2 abutments and CAD/CAM copings in the esthetic zone.

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