THE JOURNAL OF PROSTHETIC DENTISTRY

CLINICAL RESEARCH

Evaluation of the peri-implant tissues in the esthetic zone with prefabricated titanium or zirconia abutments: A randomized controlled clinical trial with a minimum follow-up of 7 years

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ABSTRACT

Statement of problem. Long-term clinical studies are lacking on the influence of the type of abutment, titanium or zirconia, on peri-implant tissues.

Purpose. The purpose of this randomized clinical trial was to evaluate peri-implant tissues with titanium or zirconia abutments.

Material and methods. A total of 26 single-tooth implant-supported prostheses in 14 participants were analyzed. They received either a titanium abutment with a metal-ceramic crown (TAG) or a zirconia abutment with a ceramic crown (ZAG). Data were collected immediately, at 5 months, and at a minimum of 7 years after crown delivery. The success rate, plaque and bleeding indexes, bleeding on probing, white and pink esthetic scores, and the relationships of the gingival phenotype with the pink esthetic score were analyzed. Statistical analyses were conducted with the *t* test for paired and independent data (α=.05).

Results. The mean follow-up time was 95.2 ±2.6 months, showing an implant success rate of 96.7%. No statistically significant differences were found between TAG and ZAG among the time intervals evaluated for plaque or bleeding indexes (P>.05). A statistically significant difference was found for peri-implant probing depths in the mid-buccal sites between the groups at all the time intervals evaluated (TAG, P=.008; ZAG, P=.021): TAG showed an increase between 5 months (3.65 ±0.93 mm) and over 7 years (4.47 ±1.32 mm); and ZAG showed a reduction (5 months=5.22 ±1.71 mm; over 7 years=4.25 ±1.28 mm) in values. For the pink (PES) and white esthetic score (WES), ZAG (PES: immediately=6.33 ±1.41; 5 months=7.44 ±1.81; over 7 years=8.25 ±1.03; WES: immediately=7.67 ±1.50; over 7 years=8.38 ±0.74) showed higher mean values than TAG (PES: immediately=5.94 ±2.35; 5 months=6.53 ±2.15; over 7 years=7.44 ±1.81; WES: immediately=7.00 ±1.17; over 7 years=8.35 ±1.27) (P<.05). Statistically significant differences were found for gingival phenotype and for PES in TAG (P=.031), and the participants with thick phenotype showed higher PES in the 3 time intervals studied.

Conclusions. Zirconia abutments exhibited better results than titanium abutments in terms of the peri-implant tissues. Moreover, in those with a thin phenotype, zirconia provided improved gingival esthetics. (J Prosthet Dent 2021;■:■-■)

Titanium (Ti) implant abutments have excellent biocompatibility and mechanical properties and can be customized for a restoration with an acceptable emergence profile.[1] However, in participants with thin gingival tissues and gingival recession,[2-4] a visible dark halo may be apparent in the cervical region because the metal abutment impedes the diffusion and reflection of light.[5-10] Ceramic zirconium dioxide (ZrO_2) abutments have become popular because of their improved esthetics, high mechanical strength, and positive impact on the health of the peri-implant soft tissues,[5,8,11-15] with reduced bacterial colonization[7,9,16] when compared with metal abutments.

Clinical criteria should be used to evaluate the peri-implant tissues and

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Clinical Implications

Improved esthetics were observed when zirconia abutments with ceramic crowns were used to restore participants with a thin gingival phenotype. Zirconia crowns also promoted an increased pink esthetic score, an objective evaluation of the peri-implant soft tissues.

implant-supported dental prostheses.[17] Various periodontal parameters, including the plaque index, bleeding index, pink esthetic score (PES), and white esthetic score (WES) have been proposed for evaluating implant outcomes. The modified plaque index and bleeding index may be used for evaluating oral hygiene and for quantifying inflammation of the peri-implant soft tissues.[18,19] Different standardized objective esthetic criteria have been proposed for the clinical evaluation of implant-supported dental prostheses. Belser et al[20] proposed scores for evaluating pink esthetics, represented by the gingiva (PES), and white esthetics, represented by the prosthetic crown (WES). These protocols facilitate evaluating the esthetic results in relation to the peri-implant tissues and the prosthesis.

A recent systematic review reported that ZrO_2 abutments tended to have improved peri-implant mucosa color and improved esthetic outcomes as measured by the PES score.[21] However, long-term studies on the clinical outcomes of Ti and ZrO_2 abutments are lacking. Therefore, this clinical study evaluated the behavior of peri-implant tissues and prostheses supported by prefabricated Ti and ZrO_2 implant abutments placed in the esthetic zone, with a follow-up period of a minimum of 7 years. The null hypothesis was that no difference would be detected in the behavior of peri-implant tissues and prostheses between the prefabricated titanium and zirconia abutments.

MATERIAL AND METHODS

This randomized, prospective, and controlled clinical trial was prepared based on the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized clinical trials and was approved by the Ethics Committee of the São Leopoldo Mandic Dental Research (no. 3.268.031) and of the Federal University of Juiz de Fora (no. 156/2010). Sixty implants were placed in 35 participants in healed alveolar bone in the premolar region, with sufficient bone for primary stabilization of the implant. Exclusion criteria were a history of chemotherapy or radiotherapy, a history of smoking, and extensive bony defects.

The participants were divided into 2 groups: Ti abutments with metal-ceramic crowns (TAG) and ZrO_2 abutments with ceramic crowns (ZAG). The participants were randomized from opaque envelopes indicating the type of treatment to be performed in that specific site.

The implants were placed by a single experienced surgeon (T.C.B.) in the appropriate 3-dimensional position[20] by means of a surgical guide, which transferred the prosthetic parameters (dental position, emergence profile, gingival margin, shape, and height) to the surgical site. The implants varied in length and diameter depending on the geometry of the site.

All participants received 1 g of amoxicillin and 100 mg of nimesulide, 1 hour before surgery. Participants allergic to amoxicillin received 500 mg of azithromycin. Immediately before surgery, all the participants rinsed with 0.12% chlorhexidine for 1 minute. After the application of local anesthesia, a mucoperiosteal flap was elevated, the site was perforated by using the manufacturer's recommended drill sequence, and the implant was placed at bone level. Then, 5-0 monofilament nylon was used to suture the repositioned flaps with mattress and simple interrupted sutures, and the sutures were removed 2 weeks postoperatively. After a 4-month osseointegration period, second-stage surgery was performed. Then, the prosthetic phase was initiated for each experimental group.

The prosthetic crowns of the TAG group were fabricated on prefabricated pure titanium metal abutments and copings. Feldspathic ceramic was applied to Ni-Cr (Fit cast-SB Plus; Talladium do Brazil), and the crown was cemented to the abutment with zinc phosphate cement (SSWhite Ltda Brazilian industry). For the ZAG group, the abutment and coping were milled in ZrO_2 with a computer-aided design and computer-aided manufacturing (CAD-CAM) subtractive milling process and cemented with a self-adhesive resin cement (RelyX Unicem; 3M ESPE).

For the clinical evaluation, data were collected at the following time intervals: T1) immediately after prosthetic delivery, T2) at 5 months, and T3) at a minimum of 7 years after the prostheses was placed in function. Osseointegration was evaluated objectively as success or failure, according to the following clinical scores[22]: score 1) absence of persistent subjective complaints such as pain or foreign body sensation and/or paresthesia; score 2) absence of recurrent peri-implant infection with suppuration; and score 3) absence of mobility.

The microbial plaque and bleeding indexes of the peri-implant sulcus were clinically evaluated by using the visual scales modified by Mombelli et al.[19] These were the plaque index (MPI) and bleeding index (MBI), with scores from 0 to 3, where "0" was the absence of plaque deposits and no bleeding when the tip of the periodontal probe was swept along the gingival margin at the implant; "1" was the presence of microbial plaque only after sweeping the probe over the free gingival margin at the implant surface or visible points of isolated bleeding; "2" was clinically visible plaque, and bleeding forms a confluent red line at the margin; and "3" was abundant plaque and profuse bleeding. The MPI and MBI indexes were measured at T2 and T3, but not at T1 as there was insufficient time for microbial plaque formation.

Esthetic evaluation was made by using the index of Belser et al[20] with the following scores: pink esthetic score (PES) for evaluating the gingival tissue around the implant; and white esthetic score (WES) for evaluating the part of the prosthetic crown that emerged from the peri-implant tissues.

For PES, the following parameters were used: 1) mesial papilla; 2) distal papilla; 3) curvature of the buccal cervical mucosa; 4) level and height of the buccal cervical mucosa; and 5) radicular convexity, color, and texture of tissue on the implant. For items 1 and 2, the scores applied were "absence," "incomplete presence," and "complete presence," whereas for items 3, 4, and 5, the scores used were "major discrepancy," "minor discrepancy," and "without discrepancy." The PES was evaluated at the 3 time intervals of the study.

For WES, the following crown esthetic parameters were used: 1) shape of tooth; 2) volume; 3) color; 4) texture of cervical buccal surface; and 5) translucency and characterization of the crown. For all the items, the scores used were "absence," "incomplete presence," and "complete presence." The WES was evaluated only at T1 and T3.

The peri-implant probing depths were measured with a North Carolina 15 periodontal probe (PCPUNC15; Hu-Friedy), which was inserted parallel to the implant body to attain the deepest point of the peri-implant sulcus by measuring the distance up to the gingival margin.[23] The probing depth was measured at T2 and T3. The participants's gingival phenotype was classified as thin or thick by determining transparency when a periodontal probe was inserted into the gingival sulcus, as recommended by De Rouck et al[24] and Frost et al.[25]

For data description, frequencies and percentages were used. To measure the central tendency and variability of the metric variables, the means and standard deviations were used. The chi-square (or Fisher Exact) tests for independent and the McNemar test for longitudinal comparison were used to compare plaque (MPI) and bleeding (MBI) indexes for the different time intervals (T2 and T3) and groups (TAG and ZAG). Repeated-measures ANOVAs were used to assess the differences between time and group for total PES and total WES. To assess the total PES and WES in the different time intervals of evaluation according to gingival phenotype, mixed model tests (fixed effects) were used. The Bonferroni post hoc test was applied to calculate interaction terms and main effects on ANOVA and mixed model tests. To compare the different time intervals, the *t* test for paired data was used, while comparisons between TAG and ZAG were made by means of the *t* test for independent data (α=.05 for all tests). The analyses were made with a statistical software program (SPSS v15.0; SPSS Inc).

RESULTS

From a total of 35 participants and 60 implants initially included in the research, 1 participant with 2 implants was excluded because the dental implant failed to osseointegrate (Fig. 1). Therefore, 33 implants were allocated to TAG, and 25 to ZAG. In the 7-year follow-up period, 15 participants were lost because of relocation, 4 because of noncompliance with follow-up visits, and 1 death.

Therefore, the sample was composed of 14 participants, the majority of whom were women (64.3%) (n=26 implants) (Table 1), who were followed up for a mean period of 95.2 ±2.6 months. The participants did not report any persistent subjective complaints (such as pain, foreign body sensation, or paresthesia), recurrent peri-implant infection with suppuration, or mobility. One zirconia abutment fractured during this study.

The 2 groups showed similar MBI and MPI in the time intervals evaluated, without any influence of the gingival phenotype (Table 2). The comparison between T2 and T3 showed an absence of significant changes for the MPI variable in group TAG (P=.453). The distribution of the data did not permit statistical analysis of the other comparisons. Table 2 highlights that the variables MPI and MBI were collected as ordinal values (0-3) and had little variance (mostly 0 and 1). Therefore, the chi-square or Fisher Exact test was used to make this analysis for independent crosstabs, and the McNemar test was used for longitudinal comparison.

The ANOVA test showed no significant interaction effect for total PES and WES according to different time intervals and groups (Figs. 2 and 3). Only main effects of time were observed (P<.05). A statistically significant difference (P<.01) was found between T1 (6.33 ±1.41) and T3 (8.25 ±1.03) for PES in the ZAG. The TAG group showed higher mean values over time (t1=7.00 ±1.17; T3=0.35 ±1.27; P<.01) (Tables 3 and 4) for WES. Tables 3 and 4 were analyzed by using repeated measures ANOVA 2×3 and 2×2, respectively. Even though the interactions were not statistically significant, the post hoc for the main effects of time were evaluated (T1 versus T3). That comparison was important considering the time elapsed between

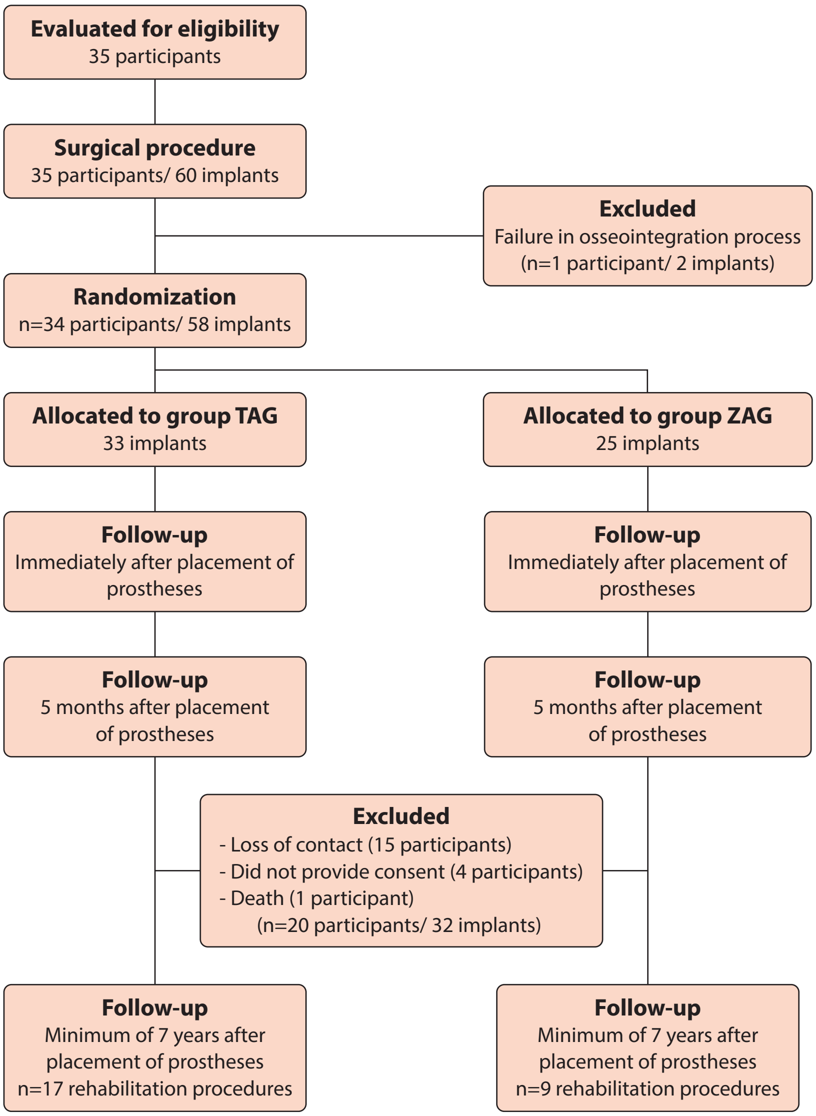

Figure 1. Study design. TAG, Ti posts with metal-ceramic crowns; ZAG, ZrO_2 posts with ceramic crowns.

evaluations (approximately 7 years) and the lack of studies in this field.

When the phenotype was added to the analysis of PES and WES, a significant interaction effect was detected for PES ($F_{2,42}$=3.37; *P*=.04). At the T2 time period, the TAG group showed a significant difference between the studied phenotypes (thick=8.40; thin=5.75; *P*=.01). A statistically significant difference was found between TAG and ZAG at T2 for the thin phenotype (*P*=.03), where the ZAG group showed higher mean values for PES. For the thick phenotype ZAG group, T3 presented significantly higher values than T1 (*P*<.01) and T2 (*P*=.02). No interaction effects were observed for WES (*P*=.11) (Table 5).

The peri-implant probing depth measurements in both groups and the 6 sites at different times, T2 and T3, are shown in Figure 4. The gingival phenotype showed statistically significant correlation only for the total PES in TAG (*P*=.031), and the participants with a thick phenotype showed higher PES in the 3 time intervals. In the TAG, the thin phenotype showed lower scores than those considered clinically acceptable (score 6) (Figs. 5 and 6).

DISCUSSION

Maintenance of the peri-implant tissues is important when evaluating the success of implant-supported crowns in the esthetic zone.[15] Therefore, in the present clinical study, the peri-implant tissues of prostheses supported by prefabricated Ti or ZrO_2 implant abutments placed in the esthetic zone were evaluated over a period of at least 7 years. Part of the null hypothesis was rejected

Table 1. Main characteristics of participants

Participants	Sex	Region Rehabilitated	Group	Gingival Phenotype	Follow-up (mo)
1	Female	Maxillary central incisor	ZAG	Thick	92
		Maxillary lateral incisor	ZAG	Thick	
2	Female	Maxillary premolar	TAG	Thick	98
3	Female	Maxillary premolar	TAG	Thin	98
4	Female	Maxillary central incisor	TAG	Thick	93
		Maxillary premolar	ZAG	Thin	
		Maxillary central incisor	TAG	Thick	
5	Male	Maxillary lateral incisor	TAG	Thick	93
		Mandibular premolar	TAG	Thin	
		Mandibular premolar	TAG	Thin	
6	Male	Mandibular premolar	TAG	Thin	96
		Mandibular premolar	TAG	Thin	
7	Female	Mandibular central incisor	TAG	Thin	96
		Mandibular premolar	TAG	Thin	
8	Female	Maxillary canine	ZAG	Thick	97
		Maxillary premolar	ZAG	Thick	
		Mandibular premolar	ZAG	Thin	
		Mandibular canine	ZAG	Thin	
9	Male	Maxillary lateral incisor	TAG	Thin	99
		Maxillary lateral incisor	TAG	Thin	
		Maxillary premolar	TAG	Thin	
10	Male	Maxillary canine	TAG	Thick	89
11	Male	Maxillary premolar	ZAG	Thick	92
12	Female	Maxillary premolar	TAG	Thin	95
13	Male	Maxillary premolar	TAG	Thin	95
14	Female	Maxillary premolar	ZAG	Thin	97

TAG, Ti posts with metal-ceramic crowns; ZAG, ZrO_2 posts with ceramic crowns.

Table 2. Absolute and relative frequencies and *P* values associated with plaque indexes (MPI) and bleeding (MBI) in different time intervals of evaluation (T2 and T3)

	T2			T3		
Findings	TAG, n (%)	ZAG, n (%)	*P*	TAG, n (%)	ZAG, n (%)	*P*
MPI	–	–	.380[a]	–	–	1.000[a]
Absence	12 (71)	8 (89)	–	15 (88)	8 (100)	–
Presence after sweeping	5 (29)	1 (11)	–	2 (12)	0 (0)	–
MBI	–	–	.399[a]	–	–	.156[b]
No bleeding	9 (53)	7 (78)	–	11 (65)	8 (100)	–
No bleeding gingival margin	8 (47)	2 (22)	–	4 (23)	0 (0)	–
Isolated bleeding	-	-	–	2 (12)	0 (0)	–

[a]Fisher Exact test. [b]Pearson chi-square test.

Figure 2. Evaluation of PES of group ZAG in time interval 1 of canine tooth. PES, pink esthetic score; ZAG, ZrO_2 posts with ceramic crowns.

Figure 3. Evaluation of PES of group ZAG in time interval 2 of canine tooth. PES, pink esthetic score; ZAG, ZrO_2 posts with ceramic crowns.

because peri-implant probing depth differences were found in the mid-buccal sites between the groups for all the time intervals evaluated. In addition, the participants with a thin gingival phenotype showed enhanced gingival esthetics when the ZnO2 abutment was used.

Damage to the external hexagon by zirconia implant abutments has been reported,[26-28] but a consensus on the causes of corrosive degradation that occurs in the dynamic environment of the oral cavity is lacking.[7,9,29] The present study did not detect structural damage to the implant or the occurrence of fracture or screw loosening.

Although ZrO_2 has been reported to retain less microbial plaque than titanium abutments in in vitro[30,31] and clinical studies[32,33] associated with the surface properties of ZrO_2 and its ability to promote proliferation of fibroblasts, resulting in improved quality of tissue adhesion, the present study observed no differences in the microbial plaque and bleeding indexes of the experimental groups over the time

Table 3. Specific PES and their respective means and standard deviations and total PES with means, standard deviations, and *P* values, according to different time intervals and groups

		Specific PES					Total PES	
Time	Group	Papilla, Mesial	Papilla, Distal	Curvature, Buccal	Height, Buccal	Convexity, Color and Texture	Means	Effects
T1	TAG	1.35 ±0.78	0.94 ±0.74	1.24 ±0.75	1.47 ±0.87	0.94 ±0.65	6,18 ±2.19	Interaction: (F2,21=2.77; *P*=.07) Intergroup: (F2,21=1.22; *P*=.28) Intragroup: (F2,21=5.45; *P*<.01)
	ZAG	1.33 ±0.70	1.11 ±0.78	1.00 ±0.50	1.67 ±0.70	1.22 ±0.44	6.37 ±1.50*	
T2	TAG	1.41 ±0.61	1.35 ±0.78	1.18 ±0.80	1.53 ±0.80	1.06 ±0.55	6.68 ±2.12	
	ZAG	1.33 ±0.70	1.44 ±0.72	1.67 ±0.70	1.67 ±0.70	1.33 ±0.50	7.37 ±1.92	
T3	TAG	1.47 ±0.71	1.06 ±0.55	1.41 ±0.79	1.41 ±0.79	1.06 ±0.74	6.50 ±2.39	
	ZAG	1.63 ±0.74	1.50 ±0.75	1.88 ±0.35	1.75 ±0.46	1.50 ±0.53	8.25 ±1.03*	

PES, pink esthetic score; TAG, Ti posts with metal-ceramic crowns; ZAG, ZrO_2 posts with ceramic crowns. *Statistically significant.

Table 4. Specific WES and their respective means and standard deviations and total WES with means, standard deviations, and *P* values, according to different time intervals and groups

		Specific WES					Total WES	
Time Interval	Group	Shape	Volume	Color	Texts	Translucence	Means	Effects
T1	TAG	1.71 ±0.47	1.59 ±0.50	1.29 ±0.47	1.18 ±0.39	1.24 ±0.43	7.00 ±1.21*	Interaction: (F1,22=1.45; *P*=.24) Intergroup: (F1,22=0.71; *P*=.41) Intragroup: (F1,22=10.29; *P*<.01)
	ZAG	1.56 ±0.52	1.78 ±0.44	1.78 ±0.44	1.11 ±0.33	1.44 ±0.72	7.75 ±1.58	
T3	TAG	1.82 ±0.39	1.76 ±0.43	1.76 ±0.43	1.47 ±0.51	1.53 ±0.51	8.37 ±1.31*	
	ZAG	1.88 ±0.35	1.88 ±0.35	1.88 ±0.35	1.13 ±0.35	1.63 ±0.51	8.37 ±0.74	

TAG, Ti posts with metal-ceramic crowns; WES, white esthetic score; ZAG, ZrO_2 posts with ceramic crowns. *Statistically significant.

intervals studied. The present study demonstrated adequate biocompatibility and low potential for microbial colonization in both study abutment groups. These findings were consistent with those of previous studies.[12,13,32,34,35] Although the reasons for these discrepancies remain obscure, the differences in the conditions of the study, the properties of the surfaces, and the fabrication of the materials tested were probably responsible for these conflicting results. In addition to the factors related to the material, the specifics of each participant such as oral hygiene, presence of caries in the adjacent teeth, gingival health index, content of their microbial flora, and levels of microbes in the saliva may have influenced plaque accumulation and bleeding.[36]

Peri-implant marginal bone remodeling is inevitable and re-establishes both vertically and horizontally compatible biological space, thereby allowing the presence of long junctional epithelium, protecting the implant-bone complex.[37] The results of the present study corroborated this theory in the sense that marginal peri-implant remodeling occurred around all the implants analyzed and were compatible with the criterion of 1 mm in the first year, as described by Albrektsson et al.[38] Peri-implant probing depths showed no differences in the majority of the sites, but, in the mid-buccal sites, a statistically significant difference and inverse behavior was found between the groups. It has been reported that biological complications may be associated with cement remnants.[39] Although biological complications were not

Table 5. Total PES and WES in different time intervals of evaluation according to gingival phenotype

	PES				WES			
	TAG		ZAG		TAG		ZAG	
Time Interval	Thick	Thin	Thick	Thin	Thick	Thin	Thick	Thin
T1	7.00	5.50	6.00a	6.75	7.60	6.75	7.20	8.25
T2	8.40B	5.75A	6.80a	8.25B	-	-	-	-
T3	7.80	5.83	8.75b	7.75	8.80	8.17	8.75	8.00
Effects	Interaction time×group×phenotype: F2,42=3.37; *P*=.04				Interaction time×group×phenotype: F1,22=2.80; *P*=.11			

PES, pink esthetic score; TAG, Ti posts with metal-ceramic crowns; WES, white esthetic score; ZAG, ZrO_2 posts with ceramic crowns. Mixed model analysis. Same letters indicate statistically similar.

reported in the present study, the presence of cement remnants may have led to an increase in probing depth, despite careful cement removal at the time of the prosthetic crown delivery.[21,40] The reduction in probing depth shown in ZAG could be associated with late epithelial adherence of the peri-implant tissues around the ZrO_2, implant abutments, as suggested by Rimondini et al.[16]

When the restorative margin extends deeply subgingival, it may influence probing depth, accumulation of the plaque, and other biological parameters. Probing depths of 5 mm or more were registered in both study groups, which showed cement line locations of 1 to 1.5 mm below the gingival line.[41] Therefore, the authors suggest that future studies consider the placement of supragingival margins of the abutments

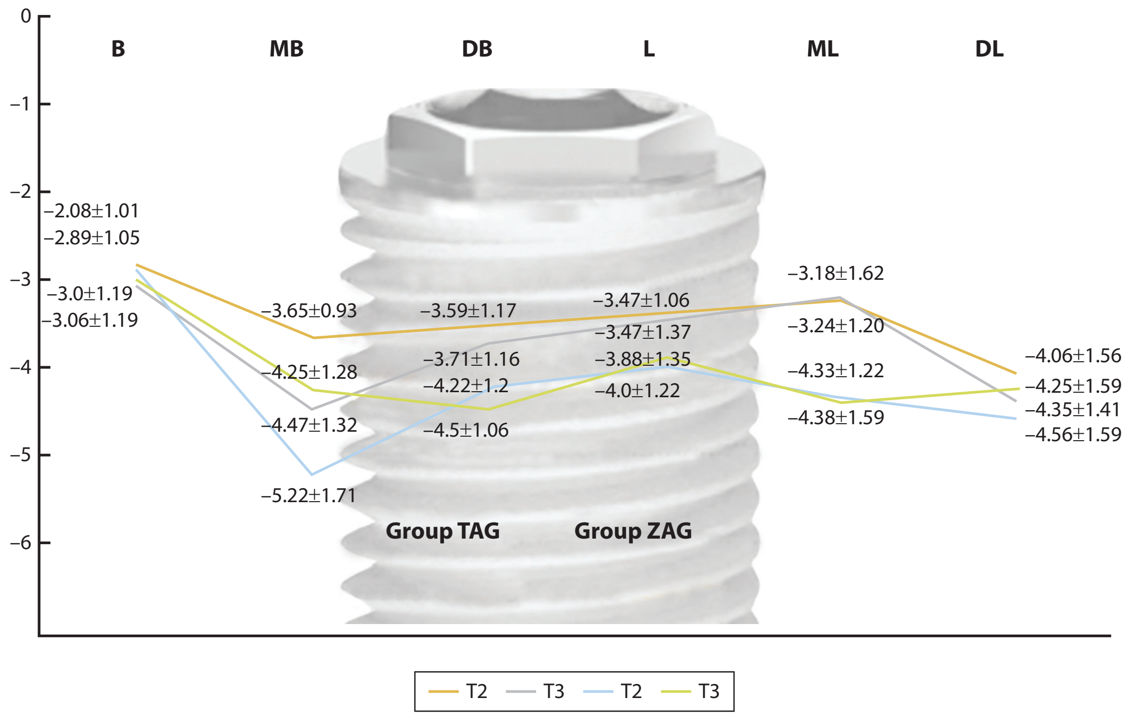

Figure 4. Probing depth (mm). B, buccal; DB, distobuccal; DL, distolingual; L, lingual; MB, mesiobuccal; ML, mesiolingual; T2, time interval 2; T3, time interval 3; TAG, Ti posts with metal-ceramic crowns; ZAG, ZrO_2 posts with ceramic crowns.

Figure 5. Evaluation of PES of group TAG in time interval of lateral incisor tooth in which grayish halo observed over cervical portion of crown in participant with thin gingival phenotype. PES, pink esthetic score; TAG, Ti posts with metal-ceramic crowns.

Figure 6. Evaluation of PES of group TAG in time interval 3 of lateral incisor tooth in which grayish halo observed over cervical portion of crown in participant with thin gingival phenotype. PES, pink esthetic score; TAG, Ti posts with metal-ceramic crowns.

to test the effect of the material on the peri-implant mucosa.[39]

The presence of thin gingival tissue and/or gingival recessions in the anterior maxillary regions led to poor appearance when a conventional titanium implant abutment was used.[2,10,15] Therefore, the use of ceramic implant abutments enhanced the PES by avoiding the appearance of a grayish line in participants with a thin phenotype.[11-13,42] This study supports this finding because ZAG had statistically higher PES than TAG. Even though the esthetics evaluation showed no statistically significant difference between the studied groups, the mean values in ZAG were higher in both time intervals evaluated. Unlike the studies of Furze et al[43] and Buser et al,[44] in which both TAG and ZAG showed acceptable esthetics in the different time intervals, the present study showed that TAG obtained a mean score below the minimum level of acceptability at T1.

CONCLUSIONS

Based on the findings of this randomized controlled clinical trial, the following conclusions were drawn:

1 After at least 7 years of follow-up, only single-tooth implant-supported rehabilitations composed of ZrO_2 implant abutments received a clinically acceptable PES.
2 The restorations with ZrO_2 implant abutments exhibited a higher level of acceptable esthetic appearance than those with implant abutments.
3 When titanium abutments were used in participants with a thin gingival phenotype, PES values were lower than those considered clinically acceptable. However, the prostheses in both groups received WES scores above the acceptable range.

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https://doi.org/10.1016/j.prosdent.2021.06.021