
Clinical evaluation of zirconium dental implants placed in esthetic areas: a case series study with up to 10 years of follow-up

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KEYWORDS

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ABSTRACT

Aim: The purpose of this study was to evaluate the esthetic result of mono-phasic zirconium dental implants, placed in the highly esthetic areas of the jaws with 10-year follow-up.

Materials and Methods: In this case series, the results of 12 monophasic zirconium dental implants placed in highly esthetic areas of 8 patients (6 male and 2 female) have been evaluated. For each implant the Pink Esthetic Score (PES) and the White Esthetic Score (WES) were evaluated. All implants were inserted in fresh post-extraction sites.

Results: The esthetic parameters PES/ WES has given a total average value of 13.79±4.54. Analyzing the two indices individually, the PES has given a value equal to 6.40±2.80 and the WES has given a value equal to 7.40±2.67. Both values obtained indicate the achievement of a satisfactory esthetic result.

Conclusion: Within the limits of this study, the zirconium dental implants seems to give excellent results with regard to the esthetic result and the maintenance of peri-implant soft tissues over time.

Introduction

Dental implant treatment is considered a safe and suitable option for the replacement of single missing teeth in the esthetic area and the demands of patients have evolved from implant survival to visually pleasing and harmonious restoration (1–3).

The increasing focus on implant aesthetics has led to the evaluation of the appearance of peri-implant soft tissue and implant-supported restorations using well-defined esthetic parameters (4,5).

Firstly, Fürhauser et al. (6) have introduced an index called Pink Esthetic Score (PES) to estimate soft tissue condition according to seven parameters: mesial papilla, distal papilla, soft tissue level, soft tissue contour, alveolar process deficit, soft tissue color and texture. Apart from soft tissue, the aesthetics of the prosthetic restoration is also important and contributes to the overall aesthetic result of the

implant treatment.

Secondly, Belser et al. (7) defined the White Esthetic Score (WES) to objectively assess the appearance of the prosthetic restoration according to five variables: tooth form, outline/volume, color, surface texture and translucency/characterization. In addition, contrary to the original proposal, the authors also modified from 7 to 5 parameters for the evaluation of PES (Table 1): mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, and root convexity/soft tissue color and texture at the facial aspect of the implant site.

To estimate the PES&WES, a 2-1-0 rating system was used to reduce the bias caused by an intermediate rating, with 2 as the maximum score and 0 as the lowest score. The five described parameters for the two indices (5 · 2) add up, under optimum conditions, to a score of 10; the threshold

Pink Esthetic Score (PES)				
	Parameter	Absent	Incomplete	Present
A	Mesial papilla	0	1	2
B	Distal papilla	0	1	2
		MAJOR DISCREPANCY	MINOR DISCREPANCY	NO DISCREPANCY
C	Curvature of facial mucosa	0	1	2
D	Level of facial mucosa	0	1	2
E	Root convexity/soft tissue color and texture	0	1	2
Maximum total PES score: 10				
White Esthetic Score (WES)				
		MAJOR DISCREPANCY	MINOR DISCREPANCY	NO DISCREPANCY
F	Tooth form	0	1	2
G	Tooth volume/outline	0	1	2
H	Color	0	1	2
I	Surface texture	0	1	2
L	Translucency	0	1	2
Maximum total WES score: 10				
Maximum total PES+WES score: 20				

Table 1 Description of PES&WES parameters

of clinical acceptability was set at 6.

The combination of PES and WES has been used to estimate the overall esthetic result of a single implant treatment, thus including both the aesthetics of the soft tissue and that of the prosthetic restoration. Due to its ease of use, the PES/WES index has gained increasing popularity as one of the standard evaluations to assess overall esthetics correctly and completely (8–11).

Both PES and WES are appraised by direct comparison with the natural and contralateral reference tooth (6,7). The difference with the natural tooth results in an unfavorable score for the implant restoration (12).

Den Hartog et al. (13) evaluated the esthetic outcome of single-tooth implants in the esthetic zone according to the pink and white esthetic score and the implant crown esthetic index and concluded that the most reproducible index seemed to be the pink and white esthetic score.

Tettamanti et al. (11) compared three different esthetic indexes for the evaluation of a single implant-supported crown and assessed the validity and the influence of the examiner's dental specialty (compared with the views of laypeople and the

patients themselves). They concluded that compared to the implant-crown esthetic index, the pink and white esthetic score and peri-implant and crown index were more reproducible and were not influenced by different observers. They also concluded that the pink and white esthetic score has been rated the fastest and the easiest to use.

Therefore, given the increasing demand for aesthetics and metal-free rehabilitation by patients, the use of ceramic materials has become increasingly widespread.

Against this background, many ceramics have been tested for dental use. Currently, yttrium-stabilized polycrystalline zirconium oxide (Y-TZP) is the material of choice for ceramic abutments (14). Zirconium oxide used for ceramic implants has proven to be significantly superior in terms of flexural strength and fracture resistance (15).

Thanks to the increasing number of commercially available ceramic implants, the clinical performance of Zirconia implants has become of great interest to the dental world. The white color and the improved imitation capacity of natural teeth have led to an improved aesthetic result (16,17). The ceramic implant is simply the result of what is already used

daily for white ceramic implant abutments and all-ceramic crowns. The use of these implants would reduce the risk of greyish titanium shadowing when the peri-implant mucosa is of thin biotype or shrinks over time (18–23).

The objective of our study is to evaluate the aesthetic result after 10 years of follow-up, using the PES&WES index, on single-component zirconia implants placed in the aesthetic area.

Materials and methods

In this study, were evaluated a total of 12 monophasic zirconium implants partially stabilized with Yttrium (White-Sky®, Bredent, Senden, Germany) placed in areas of high aesthetic value of 8 patients (6 males and 2 females) belonging to the Implant Center for Edentulism and Jawbone Atrophies, Maxillofacial Surgery and Odontostomatology Unit, IRCCS Fondazione Policlinico Ospedale Maggiore, University of Milan. The implants included are ten incisors, one canine and one first premolar.

Implant System

The implants used in this study are among the first zirconia implants put on the market: they are single-component implants with conical body, double thread and rounded apex. These are sintered and yttrium-stabilized zirconium oxide implants with an average roughness of 0.9-1 μm .

Prosthetic rehabilitation

All implants were immediately restored with acrylic provisional crowns. Six months after surgery all fixtures were loaded with a final ceramic restoration.

Esthetic evaluation

The esthetic result was evaluated taking into consideration the Pink Esthetic Score (PES) and the White Esthetic Score (WES) and readjusting them as suggested by Belser in 2009 (PES+WES) (7). For the evaluation, 4 operators were selected, other than the clinicians, who participated in the protocol and specialist in one of the following disciplines (6): Surgery, periodontology, prosthetics and orthodontics.

Evaluation of peri-implant soft tissue

By using a periodontal probe, the same operator identified the following parameters: the modified plaque index, the modified bleeding index, and probing depth.

Statistical analysis

The success rate and aesthetic appreciation of the implants were expressed as averages and standard deviations.

Results

With regard to periodontal indices, the bleeding index (mBoP) and plaque index (mPi) (24), probing pocket depth (PPD) and mobility (M) were taken into account. Evaluations were performed 6 months after surgery and then every year up to 5 years. They were then carried out again 10 years after surgery.

Considering an average follow-up period of 10 years, the overall bleeding rate was $\text{mBoP} = 0.42 \pm 0.49$; considering only implants placed in the mandible it was $\text{mBoP} = 0.35 \pm 0.48$, regarding implants placed in the upper jaw it was $\text{mBoP} = 0.49 \pm 0.50$.

With regard to the peri-implant plaque index, an average value of $\text{mPi} = 0.03 \pm 0.17$ was obtained. For the implants inserted in the mandible the mean value was $\text{mPi} = 0.04 \pm 0.2$, while in the upper jaw the implants had a mean value of $\text{mPi} = 0.03 \pm 0.17$.

Furthermore, mPI values obtained are indicative of optimal plaque control by the patients, but there is a rather high level of bleeding. Despite this, only three sites were found to have a pathological PPD. No peri-implantitis was detected. The overall average probing depth of the implants, at 120 months, was in fact equal to $\text{PPD} = 3.26 \pm 1.46$ mm, specifically equal to 2.49 ± 1.08 mm in the mandible and 3.66 ± 1.44 mm in the upper jaw. The average values of PPD recorded, respectively at 4 and 5 years of follow-up, were 3.21 and 3.0 mm; at 10 years, the total average was 3.26 ± 1.46 . The results once again demonstrate the stability of peri-implant soft tissue.

Moreover, survival criteria were identified by the permanent presence of clinically asymptomatic implants under functional loading. At the end of the 10-year follow-up, 100% survival and success rates were obtained.

Considering the overall PES/WES esthetic parameter (Table 2), the outcome is 13.79 ± 4.54 . Regard to the assessments made by each specialist, the highest scores were given by the surgeon ($\text{PES+WES} = 15.67 \pm 4.03$) and the lowest scores by the prosthetic specialist ($\text{PES+WES} = 11.58 \pm 5.58$). Intermediate assessments were given by the periodontal specialist ($\text{PES+WES} = 15.42 \pm 2.87$) and the orthodontic specialist ($\text{PES+WES} = 12.5 \pm 4.32$).

If we take PES and WES values singly (Table 3), the periodontist gave the best scores for PES with an overall average of 6.83 and the surgeon gave the best scores for WES with an average of 9. The worst scores, for PES and WES, were given by the prosthetist with averages of 5.75 and 5.83, respectively. Intermediate values were assigned by the orthodontist, with averages for PES and WES of 6.33 and 6.17 respectively.

Analyzing a single parameter of an index, it was found that, with regard to PES, the presence of the mesial and distal papilla obtained a score of 1.15 ± 0.74 and 1.33 ± 0.75 respectively. In relation

Patient	Implant	Surgery	Periodontology	Prosthetics	Orthodontics
1	21	16,00	16,00	17,00	10,00
2	12	9,00	14,00	14,00	7,00
3	24	18,00	13,00	16,00	18,00
4	22	8,00	19,00	4,00	4,00
	23	11,00	11,00	2,00	16,00
5	11	19,00	20,00	17,00	14,00
	21	19,00	20,00	17,00	14,00
6	32	17,00	14,00	4,00	11,00
	42	16,00	16,00	10,00	14,00
7	11	19,00	14,00	11,00	12,00
	12	19,00	14,00	11,00	11,00
8	41	17,00	14,00	16,00	19,00
Total average		15,67±4,03	15,42±2,87	11,58±5,58	12,5±4,32

Table 2 Overall values of PES+WES

		Total values							
		PES				WES			
Patient	Implant	Surgery	Periodontology	Prosthetics	Orthodontics	Surgery	Periodontology	Prosthetics	Orthodontics
1	21	7	6	7	8	9	10	10	2
2	12	0	4	6	2	9	10	8	5
3	24	8	7	9	8	10	6	7	10
4	22	2	9	1	3	6	10	3	1
	23	3	6	1	8	8	5	1	8
5	11	10	10	9	10	9	10	8	4
	21	10	10	9	10	9	10	8	4
6	32	7	4	1	3	10	10	3	8
	42	7	6	5	4	9	10	5	10
7	11	9	7	7	6	10	7	4	6
	12	9	6	6	5	10	8	5	6
8	41	8	7	8	9	9	7	8	10

Table 3 Total PES and WES values for each specialist

to the prosthetic restoration margin, the curvature and the level of the facial mucosa scored 1.31 ± 0.75 and 1.29 ± 0.77 respectively; the soft tissue color was 1.31 ± 0.8 . Finally, the total average result of PES was 6.40 ± 2.80 .

Considering instead the WES parameters, it was observed that the best scores were obtained for color,

translucency/characterization and outline/volume of the prosthetic restoration, which obtained a value equal to 1.67 ± 0.52 , 1.48 ± 0.65 and 1.48 ± 0.74 . The tooth form reached a value equal to 1.38 ± 0.76 . Regarding the parameter concerning the surface texture, the value was 1.40 ± 0.68 . Finally, the total average result of WES was 7.40 ± 2.67 .



Figure 1 Clinical situation of the implants on 11 and 21 at 1 year



Figure 2 Clinical situation of the implants on 11 and 21 at 5 years



Figure 3 Clinical situation of the implants on 11 and 21 at 10 years

Discussion

This clinical study presents the aesthetic results of 12 dental implants placed in the anterior area according to the concept of early loading. The cumulative survival rate was 100% after 10 years. In the literature, clinical studies on zirconia implants are few and fairly recent, and the follow-up reported is relatively short term.

All aesthetic evaluations relating to the soft tissues and implant crowns were performed by clinicians who had not been involved in any treatment.

The soft-tissue-to-implant interface is a complex structure that plays a key role in maintaining health in the peri-implant region. The maturation quality of this barrier also appears to be associated with the characteristics of the implant surface (25). An *in vitro* study (26) compared the suitability of human gingival fibroblasts based on the surfaces on which they were grown. Smooth zirconia discs allowed a rapid proliferation of fibroblasts, compared to rough zirconia discs and both rough and smooth titanium discs. In addition, on smooth zirconia discs the proliferation was much more uniform.

On smooth discs, regardless of the material, a

better alignment of the fibroblasts could be observed compared to non-smooth surfaces. Zirconia experienced better stimulation of alpha2 integrin expression at 3 hours and alpha5 integrin and type I collagen at 48 hours.

From these results it could be deduced that the wettability of the ceramic surface promotes protein assimilation and the attachment and distribution of fibroblasts on the surface (27).

These characteristics result in long-term stability of peri-implant tissues in zirconia implant rehabilitation.

From clinical evaluation, periodontal indexes showed an overall good level of peri-implant health. The radiographic evaluation showed an overall peri-implant bone loss not exceeding 1.5 mm during the first year of loading. Subsequently, from 1 year to 10 years of follow-up, MBL values were found to meet Albrektsson's criteria (28). The preservation of peri-implant bone levels may be associated with the absence of micro-gap between fixture and abutment due to the fact that the zirconia implants used in this study are characterized by a single-component design. In addition, the literature has amply demonstrated that zirconia exhibits high biocompatibility and less plaque adhesion than titanium surfaces (29–31).

The peri-implant esthetic result is influenced by the esthetic appearance of the mucosa as well as by the esthetics of the prosthetic restoration. Ideally, the peri-implant soft tissues should be in harmony with the surrounding mucosa of the adjacent teeth, and the implant crown should be well integrated with the natural teeth (32,33).

In this study, the long-term preservation of the peri-implant crestal bone and the health of the peri-implant soft tissue result in the maintenance of good esthetic results over time (Fig. 1, 2, 3). Considering all the evaluations carried out by the specialists for each case, for a total of 48, a value lower than 12 was recorded in 15 evaluations, values higher than or equal to 12 in 33 cases, 12 is the threshold value of clinical acceptability, of which 10 were higher than 18. Furthermore, the average of the specialists' evaluations for each implant was analyzed, for a total

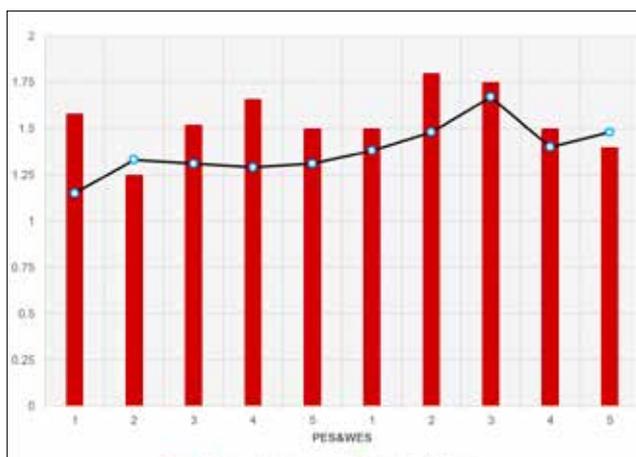


Figure 4 Comparison between the follow-up of 5 and 10 years

of 12, and it was possible to note that 8 implants gave results greater than 12 and only 4 were below the threshold value.

The evaluation of the Pink & White Esthetic Score showed an overall successful result (PES/WES=13.79±4.54). Comparing these results with the study carried out on the same case study in 2013 (17), it is possible to note that the total value of PES/WES decreased slightly, from 15.5±1.5 to 13.79±4.54, but remained above the acceptable threshold of 12 (Fig. 4).

Although extensive reports on implant rehabilitation have been published, few have documented the esthetic outcome with objective criteria (32,34,35). Since all these works described short-term results with observations of up to 1 year, we believe that the 10-year study may add relevant information. When examining the results on PES, 29% of all evaluations showed an unfavorable result (PES<6), which is higher when compared to previous short-term results (0-11%) (32,34,35), but with much shorter follow-up. On the other hand, 27% of our results showed a (almost) perfect outcome (PES>9), which reflects quite well the available data (26-39%) (32,34,35).

Four case series have been analyzed documenting the aesthetic characteristics of single implant crowns (7,35–37). In the present study 25% of the results could be considered a failure in this sense (WES<6), which is slightly higher than the range described in the literature (0-21%) (7,35–37). Moreover, 60.4% of our cases showed a very good result which is in agreement with others (35–37), but in contrast to Belser et al. (7) which shows perfection in only 18% of cases. In this regard, it should be noted that patients were referred to the dentist for prosthetic treatment.

Of particular importance is the overall aesthetic outcome combining the results of the PES and WES. As such, 20.8% showed perfection (PES+WES>=18)

which is quite modest, yet in agreement with the current knowledge on single implant treatment (7–35%) (7,35–37).

Similarly, 31,5% of our cases could be considered aesthetic failures (PES+WES<12) which also falls within the range of what has been published (5–34%) (7,35–38).

Conclusion

The results of this 10-year study indicate that single implant treatment with single component zirconia implants may be considered a valuable and predictable option in terms of implant survival and hard and soft tissue remodelling. In this context, we wish to emphasize the favorable starting point in all cases, having excluded high-risk patients with a thin gingival biotype and/or buccal bone defects. Besides careful case selection, appropriate surgical and restorative procedures and clinical experience are also considered of pivotal importance.

Since most clinical studies on zirconium oxide implants are short-term, substantial evidence supported by long-term clinical studies is required before zirconium oxide implant systems can fully replace titanium for prosthetic rehabilitation. More prospective studies monitoring soft tissue dynamics over longer time periods are needed.

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