

Five-year Success Rate of 831 Consecutively Placed Zirconia Dental Implants in Humans: A Comparison of Three Different Rough Surfaces

Josep Oliva, MS¹/Xavi Oliva, MS²/Josep D. Oliva, DM³

Purpose: The aim of this study was to evaluate the 5-year success rate of zirconia (ZrO_2) implants with three different kinds of surfaces. **Materials and Methods:** One-piece zirconia dental implants (Cera-Root) with three different roughened surfaces were designed and manufactured for this study: coated, uncoated, and acid-etched. Five different implant designs were manufactured. Standard or flapless surgical procedures were used for implant placement. Simultaneous bone augmentation or sinus elevation was performed when bone height or width was insufficient. Definitive all-ceramic restorations were placed 4 months after implant placement (8 months or more for implants when bone augmentation or sinus elevation was performed). The implants were followed up to 5 years (mean, 3.40 ± 0.21). **Results:** In all, 831 implants were placed in 378 patients with a mean age of 48 years. The overall implant success rate after 5 years of follow-up was 95% (92.77% for uncoated implants, 93.57% for coated implants, and 97.60% for acid-etched implants). The success rate of the acid-etched surface group was significantly better than that of the other two. **Conclusion:** From this midterm investigation, it can be concluded that zirconia dental implants with roughened surfaces might be a viable alternative for tooth replacement. Further follow-up is needed to evaluate the long-term success rates of the implant surfaces studied. *INT J ORAL MAXILLOFAC IMPLANTS* 2010;25:336–344

Key words: acid etching, ceramic, coating, dental implants, surface characteristics, yttria-tetragonal zirconia polycrystal, zirconia, zirconium oxide

The material of choice for dental implants is commercially pure titanium because of its well-documented biocompatibility and suitability for tooling.¹ This biocompatible material² has been used for about 30 years as an implant substrate and has shown high success rates.³

A possible alternative to titanium might be tooth-colored materials such as ceramics.^{4,5} Ceramic materials are highly biocompatible and can be used as dental devices.⁶ One ceramic material that was used in the past for dental implants is aluminum oxide (Al_2O_3).^{7,8} This material osseointegrated well but did not have sufficient mechanical properties for long-term loading,⁹ and the product was withdrawn from the market.

Recently, another ceramic material with potential for future use as a dental implant material was introduced. Zirconium oxide possesses good physical properties, including high flexural strength (900 to 1,200 MPa), hardness (1,200 Vickers), and Weibull modulus (10 to 12).^{10,11} Furthermore, its biocompatibility has been demonstrated in several animal investigations.^{12–18} Also, in vitro experiments showed that the material is capable of withstanding simulated long-term loading; however, the mechanical properties of zirconium seem to be influenced by mechanical preparation of the material.^{16,18} Moreover, the exposure of zirconium implants in the artificial mouth model has no statistically significant influence on the mean fracture strength values of the implants.^{19–21} A case report of a machined zirconium implant and zirconium crown in one patient showed an excellent esthetic result.³¹ Implant research shows that a rough surface topography is desirable to enhance the bone integration process,²² but the turning of zirconium rods results in a relatively smooth surface. Along these lines, Sennerby et al¹⁸ demonstrated better implant retrieval torque resistance for porous zirconium surfaces in rabbits; similar results were obtained by

¹Master in Periodontics, Professor Master of Periodontics, University of Barcelona, Spain.

²Master in Orthodontics, University of Barcelona, Spain.

³Private practice, Granollers, Barcelona, Spain.

Correspondence to: Dr Josep Oliva, University of Barcelona, Josep Umbert 126, Granollers 08402 Spain. Fax: +34-938792373. Email: pepeoliva@clinicaoliva.com

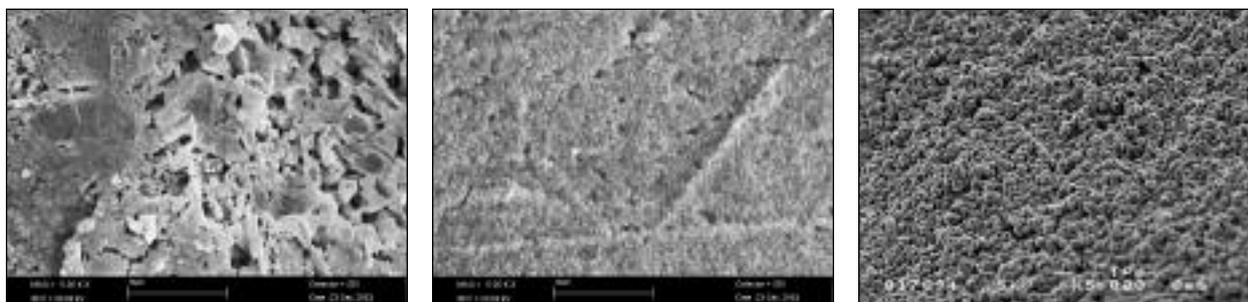


Fig 1 Scanning electron micrographs of the different studied surfaces (magnification $\times 5,000$). (Left to right) Coated surface, uncoated surface, acid-etched surface.

Gahlert et al.²³ In a systematic review, Wenz et al²¹ made several conclusions: osseointegration of yttria–tetragonal zirconia polycrystal implants (Y-TZP) might be comparable to that of titanium implants; modifications of surfaces have the potential to improve initial bone healing and resistance to removal torque; low temperature degradation might affect the behavior of Y-TZP, although this remains under investigation. Long-term clinical trials are needed to evaluate the clinical performance of Y-TZP implants before the implants are used routinely in the clinical setting. Regarding the long-term performance of Y-TZP–based restorations, there might be major differences among the systems used; Larsson et al²⁴ reported that some systems might have an unacceptable amount of veneering porcelain fractures.

The present ongoing investigation of zirconia implants (CeraRoot, Oral Iceberg) started with two kinds of rough surfaces (coated [C] and uncoated [UC]). After the new acid-etched surface (ICE) was developed, it was included in the study. The first-year preliminary results of the present study were published²⁵ and the success rate was comparable to that seen for titanium implants. Moreover, Oliva et al^{25–28} have shown the esthetic potential of this implant system in several esthetically demanding cases.

The aim of the present clinical study was to evaluate the 5-year success rate of zirconia implants with three different kinds of surfaces: C, UC, and ICE.

MATERIALS AND METHODS

This prospective study included patients between 19 and 80 years old (mean, 48.18 ± 11.60 years) who were in need of tooth replacement. Smokers of more than 10 cigarettes per day, as well as patients with a health condition or disease that might contraindicate oral surgery, including pregnancy and breastfeeding, were excluded from the study.

Table 1 Topographic Analysis of the Implants Used in the Study

Implant	Sa (μm)	Sds ($1/\mu\text{m}^2$)	Sdr (%)
UC	0.62	0.08	35.5
C	0.92	0.08	60.2
ICE	1.16	0.05	95.3

UC = uncoated; C = coated; ICE = acid-etched.

Implants

One-piece zirconia dental implants with three different rough surfaces were specially designed and manufactured for this study. In brief, cold zirconia powder (TZ-3YSB-E, Tosoh) was pressed to rods. The rods were presintered and then turned into threaded implants. To create the different surfaces on the implants, three different treatments were performed: UC, C, and ICE. The UC implants were mechanically ground with a special diamond wheel, which produced significant surface roughness ($S_a = 0.62 \mu\text{m}$).

The C implants were coated with a stable bioactive ceramic coating with the following composition: $\text{Na}_2\text{O-K}_2\text{O-MgO-Al}_2\text{O}_3\text{-CaO-SiO}_2\text{-P}_2\text{O}_5\text{-F}$. This apatite-mullite coating is specially designed for Y-TZP implants and has a documented history of use in osseointegrated implants.^{29,30} After the roughening/coating process, the implants were sintered to full density with a final roughness of $S_a = 0.92 \mu\text{m}$. Finally, the ICE implants were acid-etched, resulting in a final roughness of $S_a = 1.16 \mu\text{m}$.

Figure 1 shows the scanning electron micrographs of the three different surfaces with $5,000\times$ magnification. Standard parameters were used to characterize the different implant surfaces: S_a (absolute value of the surface departures from a mean plane); Sds (number of peaks per area unit); and Sdr (ratio between the developed surface area and a flat reference area). The ICE implants showed the highest surface roughness, followed by C and UC implants (Table 1).

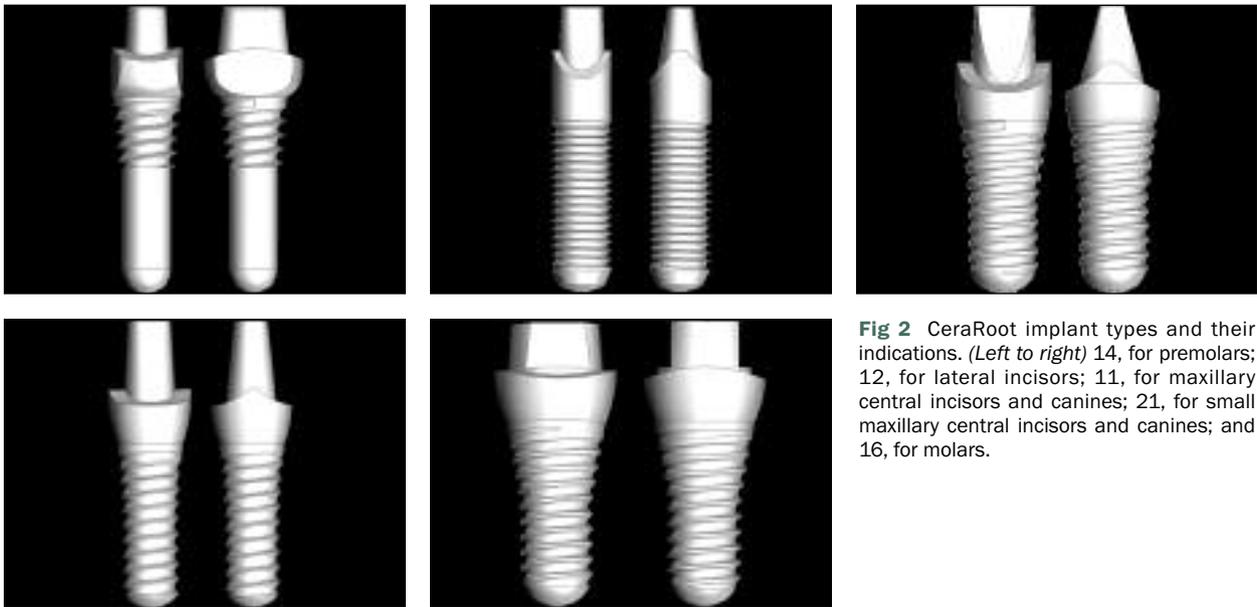


Fig 2 CeraRoot implant types and their indications. (Left to right) 14, for premolars; 12, for lateral incisors; 11, for maxillary central incisors and canines; 21, for small maxillary central incisors and canines; and 16, for molars.

Five different designs of implants were manufactured for different indications (Fig 2). Each type of implant was anatomically designed to create a perfect emergence profile for the prosthetic restoration. These one-piece implants had three distinct parts: (1) the endosseous part, with threads; (2) the transmucosal part; and (3) the abutment part, for the seating and cementation of the prosthetic restoration.

Patient Treatment

During the first year of this clinical study, patients were alternately assigned, as they were coming into the clinic, to either the C or the UC group. After the first year, the new acid-etched surface (ICE) was developed and included in the study. All patients received information about zirconia implants and the possible alternatives, and all gave their written informed consent.

Panoramic radiographs and photographs were obtained preoperatively. Casts were made and wax-ups were used to fabricate surgical stents and to determine the best implant for each situation.

If possible, the implants were placed transmucosally using a flapless technique; otherwise, standard procedures for implant placement were used. If the implants were placed immediately after tooth extraction, no incisions, flaps, or sutures were necessary. The implant sites were examined for bone fenestrations or dehiscences after site preparation; in cases where fenestrations or dehiscences were observed, a flap was raised and a bone regenerative procedure was performed simultaneously with implant placement.

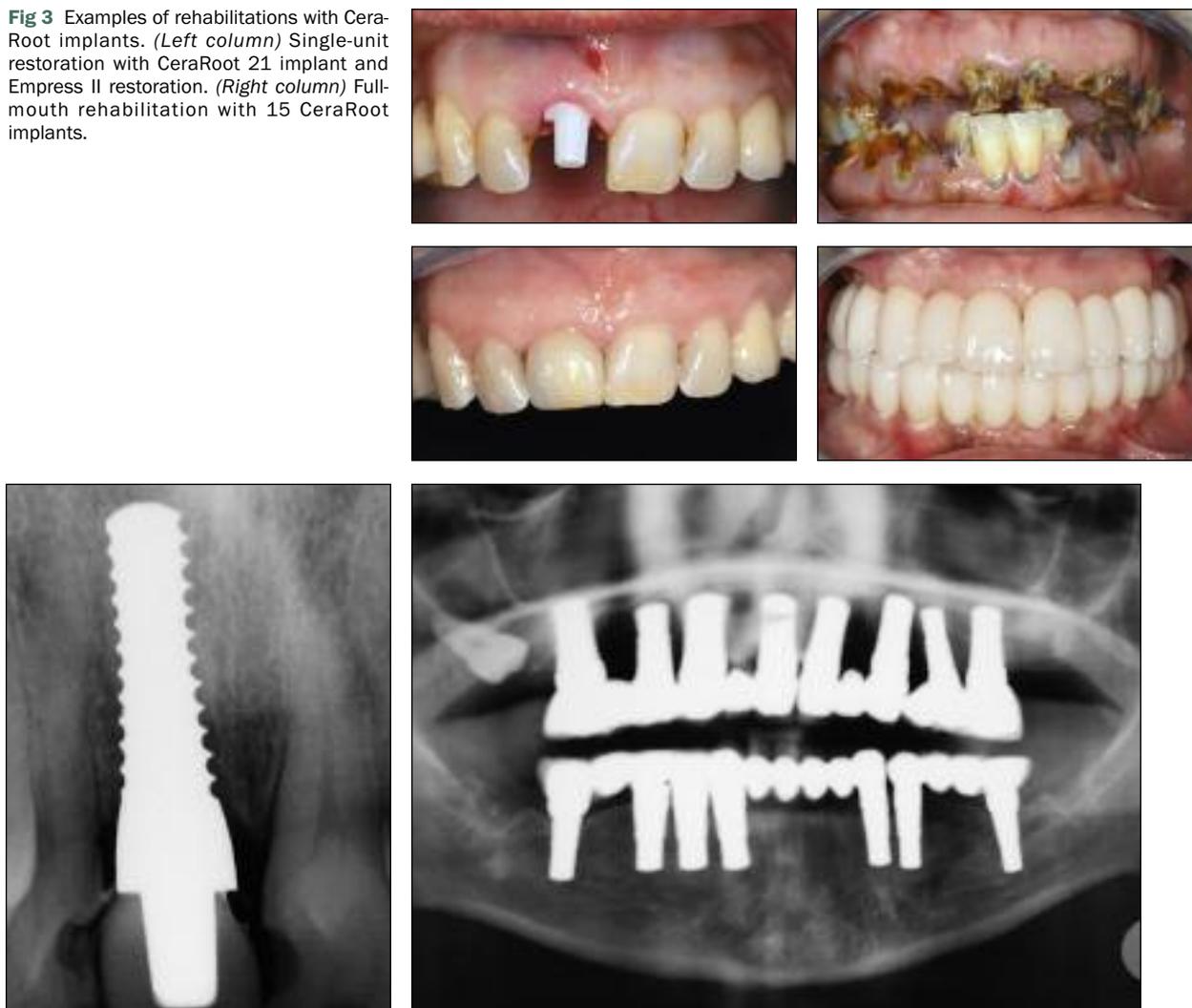
Regenerative procedures were carried out in all sites with insufficient horizontal or vertical crestal bone with autologous or demineralized freeze-dried

bovine bone. However, large defects were treated before implant placement in a two-stage approach. A simple surgical guide (vacuum stent) was used in all cases to achieve optimal positioning and inclination of the implants. The usual drill sequence was: first, initial bur; second, twist drills; and finally, a countersink. Panoramic radiographs were obtained immediately after surgery to verify implant positions.

The first choice for immediate provisional restorations was always a vacuum stent, because it served as both a provisional restoration and as a protective stent. Moreover, the simplicity of it and the fact that the implant was easily visible and accessible during the healing period were also of major importance. However, when the implants were placed in the esthetic zone (from canine to canine) using more than 35 Ncm of torque, some implants were immediately restored with a cemented provisional restoration placed slightly out of occlusion. Implants placed with lower insertion torque received only the vacuum provisional stent. Some implants that were inserted with low torque were initially cemented to the neighboring teeth, but this approach was later abandoned because of two initial implant failures during the healing period.

In the posterior maxilla, all patients with insufficient bone height (8 mm or less) received a sinus graft elevation at the time of implant placement. If the residual crestal bone height was less than 5 mm, then the implants were placed in a second stage after a sinus elevation. However, during the first year of the study, some implants were placed at the time of sinus elevation in a single stage. In these cases, the implants were splinted together with neighboring teeth or implants to avoid implant mobility and failures. This

Fig 3 Examples of rehabilitations with CeraRoot implants. (Left column) Single-unit restoration with CeraRoot 21 implant and Empress II restoration. (Right column) Full-mouth rehabilitation with 15 CeraRoot implants.



last procedure was abandoned after two early implant failures during the healing period caused by fracture of the splinting resin material.

All patients received oral hygiene maintenance instructions and were advised not to use the implants for chewing or eating during the first 2 months after surgery. The patients were seen 15 days postsurgery for follow-up and suture removal. Implants were checked for mobility, pain, and probing depth once a month, and dental hygiene was performed whenever necessary to maintain a clean and disinfected mouth. Impressions were made 3 months postsurgery when there were no regenerative procedures done.

The definitive restoration was placed 4 months after surgery, except when sinus grafting or bone regenerative procedures were performed. In regenerated sites, the implants were left to heal for much longer before insertion of the definitive ceramic restoration (small grafted sites, 6 months; large grafted sites, 11 months). All the definitive restorations were left in slight infraocclusion to compensate

for the elasticity of the periodontal ligament of natural teeth.³¹ This is especially important considering the stiffness of the ZrO₂ implants and ZrO₂ restorations, which are much more rigid compared to conventional porcelain-fused-to-metal restorations. Contacts during lateral excursions were also avoided.

All-ceramic restorations were created for all the implants included in the study. These restorations were made through the use of a computer-aided design/computer-assisted machining system (CeraRoot, Oral Iceberg) and LAVA (3M) or through the use of a pressed ceramic material (Empress II, Ivoclar Vivadent). The final cementation was performed with a resin-modified glass-ionomer cement (GC FujiCEM, GC America).

After delivery of the definitive restoration, the patients were followed up after 1, 3, 6, and 12 months and after 2, 3, 4, and 5 years. Panoramic and/or periapical radiographs were obtained regularly during checkups (Fig 3).

Table 2 Distribution of Placed Implants by Surface Type

Implant surface	Implants placed	Follow-up (range)	Gender		Regenerative procedures					Implant position				Immediate provisional (%)
			Male (%)	Female (%)	Smokers (%)	Bone graft (%)		Sinus elevation (%)		Maxilla		Mandible		
						Anterior (%)	Posterior (%)	Anterior (%)	Posterior (%)	Anterior (%)	Posterior (%)	Anterior (%)	Posterior (%)	
UC	249	3.50 ± 0.21 (2-5)	99 (39.76%)	150 (60.24%)	33 (13.25%)	55 (22.09%)	11 (4.42%)	59 (23.69%)	93 (37.35%)	25 (10.04%)	73 (29.32%)	95 (38.15%)	32 (12.85%)	
C	249	3.60 ± 0.49 (2-5)	91 (36.55%)	158 (63.45%)	42 (16.87%)	42 (16.87%)	15 (6.02%)	51 (20.48%)	99 (39.76%)	12 (4.82%)	87 (34.94%)	102 (40.96%)	35 (14.06%)	
ICE	333	3.09 ± 0.11 (1-4)	128 (38.44%)	205 (61.56%)	53 (15.92%)	65 (19.52%)	21 (6.31%)	82 (24.62%)	113 (33.93%)	22 (6.61%)	115 (34.53%)	126 (37.84%)	70 (21.02%)	
Total	831	3.40 ± 0.22 (1-5)	318 (38.27%)	513 (61.73%)	128 (15.40%)	162 (19.49%)	47 (5.66%)	192 (23.10%)	305 (36.70%)	59 (7.10%)	275 (33.09%)	323 (38.87%)	137 (16.49%)	

UC = noncoated; C = coated; ICE = acid-etched.

An implant was designated as successful if it was present with no mobility, no pain, no peri-implant mucositis, no peri-implant bone loss, and no implant fracture.

Statistical Analysis

The chi-square test was used to calculate statistical differences between the C, UC, and ICE surface groups. P values less than .05 were considered significant.

RESULTS

Three hundred seventy-eight patients (227 women [60.05%] and 151 men [39.95%]) received a total of 831 implants (513 in women [61.73%] and 318 in men [38.27%]). Of the 831 implants placed, 249 were UC, 249 were C, and 333 were ICE. The mean follow-up period was 3.40 ± 0.21 years. A total of 128 implants (15.40%) were placed in smokers (who smoked fewer than 10 cigarettes/day). One hundred sixty-two implants (19.49%) were placed in combination with a bone graft and 47 implants (5.66%) were placed simultaneously with a sinus elevation. One hundred ninety-two implants (23.10%) were placed in the anterior maxilla, 305 (36.70%) were placed in the posterior maxilla, 59 (7.10%) were placed in the anterior mandible, and 275 (33.09%) were placed in the posterior mandible. Three hundred twenty-three implants (38.87%) were placed using a flapless surgical technique. One hundred thirty-seven implants (16.49%) received a fixed immediate provisional restoration. Table 2 shows the distribution of implants among the UC, C, and ICE surfaces.

Within the limits of this study, the overall 5-year success rate of the 831 implants was 94.95%. By group, the success rates were 92.77% for the UC implants, 93.57% for the C implants, and 97.60% for the ICE implants. The differences were statistically significant between the UC and ICE groups as well as between the C and ICE groups. There were no significant differences in the survival rate between screwed-in (types: 11, 21, 12, 16) and tapped-in implants (type 14).

A total of 42 implants (5.05%) failed; 29 (69.05%) were lost in smokers, 8 implants (19.05%) were grafted, and 9 (21.43%) failed after placement with simultaneous sinus elevation. Six implants (14.29%) failed in the anterior maxilla, 16 (38.10%) in the posterior maxilla, 3 (7.14%) in the anterior mandible, and 17 (40.48%) in the posterior mandible. Thirty-eight implants (90.48%) failed before the first year. Four implants (9.52%) failed between the first and second years, and no implants were lost after the second year. Four implants (9.52%) that failed had been placed with a flapless surgery. Four implants (9.52%)

that failed had received an immediate provisional restoration. No fractures of implants were reported in any of the groups. Table 3 represents the distribution of failed implants among the different groups.

DISCUSSION

Osseointegration of threaded zirconia implants has been demonstrated in various animal models. Akagawa et al¹³ compared the bone tissue response to loaded and unloaded zirconia implants in the dog mandible. The authors reported a high degree of bone-implant contact 3 months after placement, with no differences between the groups. In a monkey model¹⁴ Akagawa et al examined the long-term stability of partially stabilized zirconia implants placed in a one-stage procedure with different loading designs. No clear difference in clinical features was observed among the different types of support. Direct bone apposition to the implant was generally seen in all groups. Histometrically, no differences were seen between groups. No mechanical problems, such as fracture of the implants, were reported, confirming the favorable mechanical properties of zirconia.

Kohal et al¹⁷ compared custom-made titanium and zirconia implants used to support metal crowns in the maxillae of six monkeys. Both implant types were sandblasted, and the titanium was also acid-etched. All implants achieved and maintained stability, and no mechanical problems were reported. Histologic examinations revealed no differences in the bone tissue response to the titanium and zirconia implants.

In another study, Kohal et al¹⁶ reported a three-dimensional computerized stress analysis of commercially pure titanium and yttrium-partially stabilized zirconia (Y-PSZ) implants. The results showed that Y-PSZ implants had very similar stress distribution to that of commercially pure titanium.

Sennerby et al¹⁸ reported a study of surface-modified (coated) zirconia implants on rabbits. A strong bone tissue response to surface-modified zirconia implants was seen after 6 weeks of healing. The modified zirconia implants showed a resistance to torque forces similar to that of oxidized implants and a four- to fivefold increase compared with machined zirconia implants. The findings suggested that surface-modified zirconia implants can reach firm stability in bone.

Other ceramics, such as aluminum oxides, have been used as dental implants. Clinical follow-up studies of the Tübingen^{6,7} implant showed survival rates from 80% to over 90%. However, this implant was later withdrawn from the market, possibly because of problems with mechanical failure.

Table 3 Distribution of Failed Implants by Surface Type

Implant surface	Implants placed	No. of failures	% failure (success)	Gender		Smokers (%)	Bone graft (%)	Sinus elevation (%)	Maxilla		Mandible		Failure date <1y ≤2y >2y	Flapless (%)	Immediate provisional (%)		
				Male (%)	Female (%)				Anterior (%)	Posterior (%)	Anterior (%)	Posterior (%)					
UC	249	18	7.23% (92.77)	9 (50.00%)	9 (50.00%)	11 (61.11%)	4 (22.22%)	3 (16.67%)	2 (11.11%)	7 (38.89%)	1 (5.56%)	8 (44.44%)	17	2	0	2 (11.11%)	2 (11.11%)
C	249	16	6.43% (93.57)	6 (37.50%)	8 (62.50%)	12 (75.00%)	2 (12.50%)	4 (25.00%)	2 (12.50%)	7 (43.75%)	1 (6.25%)	6 (37.50%)	13	2	0	1 (6.25%)	2 (12.50%)
ICE	333	8	2.40%* (97.60)	3 (37.50%)	5 (62.50%)	6 (75.00%)	2 (25.00%)	2 (25.00%)	2 (25.00%)	2 (25.00%)	1 (12.50%)	3 (37.50%)	8	0	0	1 (12.50%)	0 (0.00%)
Total	831	42	5.05% (94.95)	18 (42.86%)	22 (57.14%)	29 (69.05%)	8 (19.05%)	9 (21.43%)	6 (14.29%)	16 (38.10%)	3 (7.14%)	17 (40.48%)	38	4	0	4 (9.52%)	4 (9.52%)

UC = noncoated; C = coated; ICE = acid-etched.

*Statistically significant.

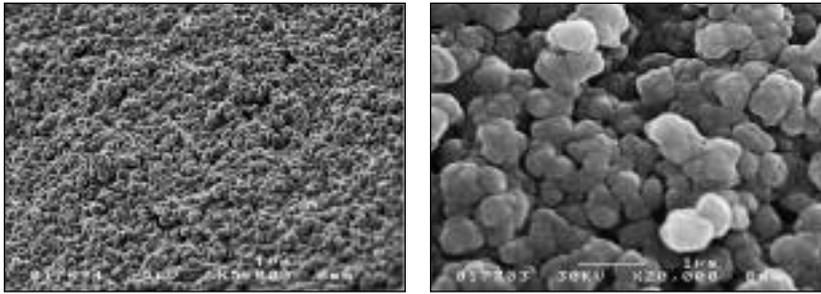


Fig 4 Scanning electron micrographs of CeraRoot with ICE surface (*left*: magnification $\times 5,000$; *right*: magnification $\times 20,000$).

Table 4 Results of ISO 14801 Static and Dynamic Testing with CeraRoot Implant¹¹ (12-mm length)

Sample no.	Compressive load (N)	Result	No. of cycles
1	2,874	Fracture	Static
2	2,948	Fracture	Static
3	2,185	Fracture	Static
4	2,915	Fracture	Static
5	2,700	Fracture	1,000
6	2,200	Fracture	5,000
7	2,100	Fracture	12,000
8	1,900	Fracture	3,361,000
9	2,300	Fracture	4,273,000
10	1,800	No fracture	5,000,000
11	2,200	No fracture	5,000,000
12	1,900	No fracture	5,000,000

There is sufficient evidence that zirconia ceramics are highly biocompatible and have the mechanical properties required to serve well as materials for dental implants.^{10,16} However, the clinical experience of zirconia implants is limited to a few case reports. Kohal and Klaus³¹ reported on a patient rehabilitated with a zirconia dental implant. The authors extracted a hopeless maxillary central incisor and immediately placed a zirconia implant with bone graft to fill the bone defect that was present. After the bone healed for 6 months, an abutment was cemented onto the zirconia implant and the definitive restoration was placed. The final radiographic and esthetic outcome achieved was very satisfactory. At the 1-year follow-up examination, the peri-implant bone and gingiva levels were stable.

Modern implant research shows that a rough surface topography is desirable to enhance the bone integration process,^{18,21–23} as described earlier. Along these lines, in the present study three different rough surfaces were studied and compared: uncoated, coated, and acid-etched.

In this study, occlusion was considered an important factor for success, especially during the restorative phase of treatment and the follow-up period. The

occlusion of ZrO₂ implants in combination with all-ceramic restorations must be considered as a more rigid occlusal element compared to a natural tooth. In this sense, large occlusal forces may induce intrusion, pain, grinding, or even fracture of the antagonist teeth.³² Therefore, it is important to leave the restorations slightly in infraocclusion. After cementation of the definitive restoration, the occlusion should be checked with the occlusal paper, first with normal chewing forces; occlusal adjustment can then proceed under large biting forces. Moreover, the occlusion should be checked routinely during posttreatment control examinations. Additionally, it makes sense to provide bruxing patients with a rigid occlusal stabilization splint (nightguard).³³

In this study, a total of 831 implants was placed in 378 patients with a mean age of 48 years. This disparate group of patients was included in the study to reflect the nature of a private practice. Nevertheless, there was homogeneity between the groups. The overall implant success rate after 5 years of follow-up was 95% (92.77% for the UC implants, 93.57% for the C implants, and 97.60% for the ICE implants). The success rate of the ICE surface group was significantly better than the those obtained in other two groups. In addition, the ICE surface presented the highest roughness values (Table 1); this could be a reason why this surface showed clinically superior performance. A larger magnification of the acid-etched ICE surface can be seen in Fig 4.

A total of 42 implants (5.05%) failed during the 5-year period (UC: 7.23%; C: 6.43%; ICE: 2.40%). There were no fractured implants. Moreover, the authors mechanically tested the CeraRoot implant type 11 in the 12-mm length, according to ISO 14801.³⁴ Twelve implants were tested for static loading (four implants) and dynamic loading (eight implants) at an angle of 30 degrees. The static load at fracture of the implants ranged from 2,185 to 2,948 N. The dynamic load without fracture at 5 million cycles ranged from 1,800 to 2,200 N (Table 4). Within the limits of this 5-year study, it seems that the mechanical properties of the CeraRoot zirconia implants are appropriate for dental implants and might be a good alternative for tooth replacement with long-term success.

1. Patient Selection.
 - a. INDICATIONS:
 - Good oral and general health
 - Absence of metal allergies
 - Single or multiple-unit restorations
 - Full-arch restorations rehabilitated by sextants
 - Good occlusion
 - Immediate implants
 - Transmucosal implantation
 - Immediate provisionals placed out of occlusion; a removable vacuum stent is always the first choice
 - b. CONTRAINDICATIONS:
 - Smokers of more than 10 cigarettes per day
 - Crossbites, parafunctions
 - Active periodontitis
 - Significant horizontal and/or vertical bone loss should be regenerated before implant placement, with implants placed in a second stage
 - Full-arch rehabilitations with a one-piece restoration
 - Immediate loading should be avoided
 - Immediate provisionals in the posterior areas should be avoided
2. Preoperative Planning.
 - Meticulous initial examination, with multidisciplinary approach
 - Stone models in the articulator and a wax-up of the intended definitive restoration
 - Photographs
 - Panoramic radiographs, with periapical and computed tomography when needed
 - Sufficient bone (height and width) available for implant anchorage
 - Implant model selection (see manufacturer recommendations)
 - Prepare a surgical guide (a simple vacuum stent could be enough)
 - Prepare a protective stent for the healing period (vacuum)
3. Surgery.
 - Good oral health conditions; pay special attention to hygiene conditions
 - No smoking for 15 days before and after surgery
 - Antibiotic coverage
 - Use a surgical guide to ensure optimal positions and inclinations of implants
 - Use CeraRoot drilling sequence according to the implant type
 - Sinuses with less than 8 mm of residual alveolar bone should be grafted and implants placed at least 6 months later
 - Horizontally resorbed alveolar ridges with insufficient residual bone should be grafted and implants placed in a second stage; after implant site preparation, at least 1.5 mm of residual bone should remain circumferentially around the implant, especially in the buccal and lingual aspects; check implant type and diameter before surgery
4. Provisional Restorations.
 - Immediate implants are safe when (1) no active infection is present, (2) there is enough bone and no fenestrations, and (3) good primary stability can be achieved
 - Radiographs should be used to confirm good implant position
 - Postoperative antibiotic coverage (4 days) and analgesics can be used if needed
 - Delivery of the protective stent: it should be worn 24 hours a day for 2 months, including meals and sleep, and should only be removed after meals for cleaning; if during the 2 months this stent breaks down it should be replaced
5. Healing Period.
 - First choice is always the protective stent, where a provisional tooth can be added, for example, with some resin or composite
 - Cemented fixed restorations can be delivered in the anterior region for esthetic reasons, taking into considerations that it is more risky than the first choice; conventional temporary cement can be used; it is very important to keep it out of occlusion in centric, lateral, and protrusive excursions; do not remove the provisional restorations for 3 months to minimize the risk of implant mobility
6. Definitive Restoration.
 - Should not be delivered before 3 months after surgery, to obtain soft tissue stability
 - Zirconia-based restorations or Empress II restorations are indicated
 - Do not use porcelain-fused-to-metal restorations
 - Fuji Cem II (GC America) is recommended for the final cementation of zirconia restorations; Empress II restorations can be cemented with Cem Kit (Ivoclar-Vivadent)
 - Radiography should be used to confirm the fit of the restoration(s)
7. Maintenance.
 - Check ups after 1, 3, and 6 months
 - Annual periapical radiographs
 - Regular dental hygiene
 - All potential bruxers should be advised to wear a rigid protective nightguard to avoid implant and restorative failures

Fig 5 Protocol and recommendations for the CeraRoot implant system.

After 831 CeraRoot implants were placed and followed for up to 5 years with good success, it seems appropriate to establish a protocol for placing the CeraRoot implants with a higher confidence of success. This protocol is described schematically in Fig 5.

CONCLUSIONS

CeraRoot acid-etched implants (ICE surface) showed a long-term clinical performance of 97.60% under the described protocol. Zirconia implants might be a good alternative for tooth replacement.

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