Clinical Evaluation of Zirconia-Based Restorations on Implants: A Retrospective Cohort Study from the AIOP Clinical Research Group

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Purpose: The aim of this retrospective cohort study was to evaluate the clinical performance of zirconia-based implant-supported single crowns and fixed dental prostheses (FDPs) made by 15 members of the Italian Academy of Prosthetic Dentistry (AIOP) over a time period of up to 5 years. ***Materials and Methods:*** One hundred thirty-one patients were treated with a total of 210 zirconia-based single crowns and FDPs on implants in anterior and posterior regions. A cohort group with parafunctional habits was compared with patients without parafunctional habits according to the esthetic, functional, and biologic United States Public Health Service criteria modified by the FDI World Dental Federation. ***Results:*** The estimated cumulative survival (ECS) and standard error (SE) of all restorations on implants was 91.95% ± 1.39%, and the estimated cumulative success (ECSs) and SE was 88.37% ± 1.72%. The ECS of single crowns and FDPs was 91.25% ± 3.69% and 95.23% ± 2.28%, respectively, and the estimated cumulative success rates were 88.84% ± 2.05% and 87.96% ± 3.16%, respectively. Mechanical failures, including four zirconia core fractures, three hairline cracks, four chippings, and five delaminations of the ceramic veneering material, were recorded during a 1- to 5-year observation period. The odds ratio of 3.39 (95% confidence interval: 1.18 to 9.73) showed a moderate association between parafunction and failure. ***Conclusions:*** Zirconia-based implant-supported restorations showed encouraging clinical results over a period of up to 5 years, but more clinical data are needed before these restorations can be considered a viable treatment alternative. Mechanical failures were primarily observed in patients with parafunctions. *Int J Prosthodont 2015;28:239–242. doi: 10.11607/ijp.4038*

The mechanical, physical, and chemical properties of zirconia in combination with computer-aided design/computer-assisted manufacturing (CAD/CAM) are potentially favorable to extend its applications for implant-supported restorations. In addition, promising clinical data for zirconia tooth-supported fixed dental prostheses (FDPs) in combination with their biologic properties has encouraged clinicians to use zirconia as an abutment,[1] and recently it has been proposed as a substitute for titanium in implant dentistry.[2] However, clinical failures of zirconia restorations due to technical complications such as chipping, delamination of the ceramic veneering, and fracture of the zirconia core have prompted a controversial discussion about substituting zirconia for metal. The lack of information on the behavior at the interface between titanium and zirconia, the rigidity of the complex implant-abutment restoration, and the absence of proprioception in combination with high chewing forces could increase the fracture of the core and/or veneering porcelain.[3] The aim of this study was to evaluate the 1- to 5-year clinical outcome of zirconia-based single crowns and FDPs on implants performed in general dental practice in an attempt to establish major risk factors that may contribute to restoration failure.

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Table 1 Life Table Analysis of the Estimated Cumulative Survival (ECS) of 149 Zirconia-Based Implant-Supported Single Crowns

	Anterior				Posterior				Total			
Time (y)	no.	Censored	Failed	ECS ± SE (%)	no.	Censored	Failed	ECS ± SE (%)	no.	Censored	Failed	ECS ± SE (%)
0–1	46	0	1	97.82 ± 2.15	103	1	1	99.02 ± 0.96	149	1	2	98.65 ± 0.94
1–2	39	2	0	97.82 ± 2.15	65	0	3	94.44 ± 2.73	104	2	3	95.76 ± 1.86
2–3	21	0	0	97.82 ± 2.15	36	0	1	91.81 ± 4.79	57	0	1	94.08 ± 2.47
3–4	10	0	0	97.82 ± 2.15	23	0	1	87.82 ± 7.34	33	0	1	91.22 ± 3.69
4–5	5	0	0	97.82 ± 2.15	15	0	0	87.82 ± 7.34	20	0	0	91.22 ± 3.69

Table 2 Life Table Analysis of the Estimated Cumulative Success (ECSs) of 149 Zirconia-Based Implant-Supported Single Crowns

	Anterior				Posterior				Total			
Time (y)	no.	Censored	Failed	ECSs ± SE (%)	no.	Censored	Failed	ECSs ± SE (%)	no.	Censored	Failed	ECSs ± SE (%)
0–1	46	0	1	97.82 ± 2.15	103	1	2	98.04 ± 1.36	149	1	3	97.97 ± 1.15
1–2	39	2	1	95.23 ± 3.00	65	0	4	92.00 ± 2.30	104	2	5	93.20 ± 2.32
2–3	21	0	0	95.23 ± 3.00	36	0	1	89.44 ± 2.48	57	0	1	91.56 ± 2.80
3–4	10	0	0	95.23 ± 3.00	23	0	1	85.53 ± 2.63	33	0	1	88.78 ± 3.85
4–5	5	0	0	95.23 ± 3.00	15	0	0	85.53 ± 2.63	20	0	0	88.78 ± 3.85

Table 3 Life Table Analysis of the Estimated Cumulative Survival (ECS) of 61 Zirconia-Based Implant-Supported FDPs

	Anterior				Posterior				Total			
Time (y)	no.	Censored	Failed	ECS ± SE (%)	no.	Censored	Failed	ECS ± SE (%)	no.	Censored	Failed	ECS ± SE (%)
0–1	17	0	0	100.00 ± 0.00	44	1	0	100.00 ± 0.00	61	1	0	100.00 ± 0.00
1–2	12	0	0	100.00 ± 0.00	30	0	2	93.33 ± 3.14	42	0	2	95.23 ± 2.28
2–3	1	0	0	100.00 ± 0.00	18	0	0	93.33 ± 3.14	19	0	0	95.23 ± 2.28
3–4	0	-	-	-	6	0	0	93.33 ± 3.14	6	0	0	95.23 ± 2.28
4–5	0	-	-	-	1	0	0	95.45 ± 3.14	1	0	0	95.23 ± 2.28

FDPs = fixed dental prostheses.

Materials and Methods

One hundred thirty-one patients (mean age: 53 years, range: 20 to 86 years) were treated with 210 zirconia-based restorations on dental implants. Seventeen anterior and 44 posterior restorations were restored with FDPs. Twenty-six FDPs were screw-retained and 35 were cement-retained. Forty-six anterior and 103 posterior restorations were single crowns; 49 single crowns were screw-retained and 100 were cement-retained. The details of the materials and methods were described in a previous study by Monaco et al.[4] Among the patients, 89 showed no parafunctions, whereas 28, 8, and 6 showed light, moderate, and severe parafunctional habits, respectively. This classification was based on an interview with the patients and an examination of their tooth wear facets. Esthetic, functional, and biologic United States Public Health Service parameters modified by the FDI World Dental Federation study design were collected, and each parameter was ranked in four subgroups. Estimated cumulative survival (ECS) was defined as the restoration remaining in situ irrespective of scores of 1, 2, or 3 for esthetic, functional, and biologic parameters, whereas it was considered a failure when the restoration obtained a score of 4. Chipping of the ceramic veneering material (grade 1 to 2) was not considered failure because it is at least theoretically repairable. Chipping scores of 3 or 4 in addition to scores of 4 for other parameters were considered terminal events for estimated cumulative success (ECSs) analysis. Life tables were generated using Kaplan-Meier analysis and SPSS version 21 statistical software (IBM). The odds ratios (OR) of the subgroups of patients with parafunctions were calculated.

Results

The ECS of all zirconia-based restorations from 1 up to 5 years was 91.95% ± 1.39%, and the estimated cumulative success rate was 88.37% ± 1.72%. The ECS rates of single crowns and FDPs were 91.25% ± 3.69% and 95.23% ± 2.28%, respectively (Tables 1 and 3) and the ECSs were 88.84% ± 3.85% and

Table 4 Life Table Analysis of the Estimated Cumulative Success (ECSs) of 61 Zirconia-Based Implant-Supported FDPs

	Anterior				Posterior				Total			
Time (y)	no.	Censored	Failed	ECSs ± SE (%)	no.	Censored	Failed	ECSs ± SE (%)	no.	Censored	Failed	ECSs ± SE (%)
0–1	17	0	0	100.00 ± 0.00	44	1	0	100.00 ± 0.00	61	1	0	100.00 ± 0.00
1–2	12	0	1	91.66 ± 5.70	30	0	2	93.33 ± 3.14	42	0	3	92.85 ± 2.76
2–3	1	0	0	91.66 ± 5.70	18	0	1	88.11 ± 3.80	19	0	1	87.96 ± 3.16
3–4	0	-	-	-	6	0	0	88.11 ± 3.80	6	0	0	87.96 ± 3.16
4–5	0	-	-	-	1	0	0	88.11 ± 3.80	1	0	0	87.96 ± 3.16

Table 5 Clinical Parameters and Complications of Implant-Supported Zirconia Single Crowns in Terms of Esthetic and Functional Properties

Properties		Parameters	Anterior no.	Posterior no.	Total
Esthetic properties					
Surface luster	1	Surface luster comparable to enamel	36	92	128
	2	Slightly dull, not noticeable if covered with film of saliva	10	11	21
	3	Dull, cannot be masked by saliva film	–	–	0
	4	Rough surface, unacceptable plaque retentive surface	–	–	0
Functional properties					
Framework fracture	1	No	45	100	145
	4	Yes	1	3	4
Fracture of ceramic veneering	1	No	45	98	143
	2	Yes, hairline crack/small chipping (grade 1: polishable)	–	1	1
	3	Yes, chipping (grade 2: repairable)	1	1	2
	4	Yes, severe chipping/delamination (grade 3: replacement)	–	3	3
Patient's view	1	Entirely satisfied	32	73	105
	2	Satisfied	12	27	39
	3	Minor criticism of esthetics; no adverse effect	2	3	5
	4	Completely dissatisfied and/or adverse effect, including pain	–	–	–

1 = clinically excellent/very good; 2 = clinically good; 3 = clinically sufficient/satisfactory; 4 = clinically unsatisfactory.

Table 6 Clinical Parameters and Complications of the Implant-Supported Zirconia-Based FDPs in Terms of Esthetic and Functional Properties

Properties		Parameters	Anterior no.	Posterior no.	Total
Esthetic properties					
Surface luster	1	Surface luster comparable to enamel	17	40	57
	2	Slightly dull, not noticeable if covered with film of saliva	0	4	4
	3	Dull, cannot be masked by saliva film	0	0	0
	4	Rough surface, unacceptable plaque retentive surface	0	0	0
Functional properties					
Framework fracture	1	No	17	44	61
	4	Yes	0	0	0
Fracture of ceramic veneering	1	No	16	39	55
	2	Yes, hairline crack/small chipping (grade 1: polishable)	0	2	2
	3	Yes, chipping (grade 2: repairable)	1	1	2
	4	Yes, severe chipping/delamination (grade 3: replacement)	0	2	2
Patient's view	1	Entirely satisfied	17	38	55
	2	Satisfied	0	6	6
	3	Minor criticism of esthetics; no adverse effect	0	0	0
	4	Completely dissatisfied and/or adverse effect, including pain	0	0	0

1 = clinically excellent/very good; 2 = clinically good; 3 = clinically sufficient/satisfactory; 4 = clinically unsatisfactory.

87.96% ± 3.16%, respectively (Tables 2 and 4). Tables 5 and 6 show the failures and complications for single crowns and FDPs, respectively. The OR for all restorations was 3.39 (95% confidence interval: 1.18 to 9.73) with a moderate association between parafunction and failure.

Discussion

Clinical data concerning zirconia-based restorations on implants are few and controversial. The short-term results of older studies recorded fracture rates of the veneering ceramic ranging from 7.5% to 18.5% after 6

and 15.3 months in single crowns, and more dramatic data were reported with even higher veneer failure rates of 41% to 53% after 12 and 13 months in implant-supported zirconia-based FDPs. However, no zirconia framework fractures were recorded in the two different types of restoration.[3] In the present study, four zirconia core fractures, five delaminations, and four chippings were found, often in combination with parafunctional habits. No correlations were found between mechanical failures and screw-retained or cement-retained restorations. In eight cases of failure, the antagonist tooth was restored with a ceramic-based implant not involved in the mechanical breakdown. A recent 5-year randomized controlled trial on single implants that compared zirconia and titanium abutments supporting zirconia and metal-ceramic crowns, respectively, showed no clinical differences between the two groups for estimated survival or technical and biologic complications.[5]

Conclusions

Currently, the short- to medium-term follow-up results of zirconia-based restorations supported by implants are promising, but there are limited clinical data. Failures were limited and occurred primarily in patients with parafunctions. More clinical data, including randomized controlled trials, are needed to assess the suitability of zirconia-based restorations instead of metal in implant dentistry.

Acknowledgments

The authors reported no conflicts of interest related to this study.

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Literature Abstract

Predictors of alveolar process remodeling following ridge preservation in high-risk patients

The aim of this study was to evaluate the remodeling of alveolar bone in its horizontal dimension after a ridge-preservation procedure was carried out in patients with either incomplete buccal bone wall or thin- scalloped gingiva or both. Forty-two adult patients were included in the study and all were in need of a single implant in the anterior maxilla. All patients selected had incomplete buccal bone wall and/or including thin- scalloped gingival biotype. Teeth were atraumatically extracted and collagen-enriched bovine xenograft blocks were fashioned and fitted into the alveolus without usage of a membrane. Comparisons of the baseline versus 4 month post-operative measurements of the buccopalatal dimension of the alveolar process were made on occlusal digital slides superimposed over each other. The change was expressed as a percentage of baseline measurements. Mean alveolar process remodeling was 14%, signifying that shrinkage had occurred in all cases, however, all patients did not require any additional bone augmentation during subsequent implant placement. Central incisors and canines, teeth with abscesses, and buccal bone loss were found to be significant predictors for alveolar volume loss during remodeling. The authors acknowledged that this study faced certain limitations with regards to accuracy of measurements using superimposed clinical slides without histologic evidence and not being a randomized controlled trial. The results showed that volume loss occurs to an acceptable extent after ridge preservation and, in addition, tooth location, presence of infection, and buccal bone loss are significant predictors of remodeling.

Cosyn J, Cleymaet R, De Bruyn H. *Clin Implant Dent Relat Res* 2014 July 17. doi: 10.1111/cid.12249. **References:** 28. **Reprints:** Prof Jan Cosyn, Faculty of Medicine and Health Sciences, Dental School, Department of Periodontology and Oral Implantology, University of Ghent, De Pintelaan 185, Ghent B-9000, Belgium. Email: jan.cosyn@ugent.be—*Debbie P.M. Hong, Singapore*