Survival Rates and Complications for Zirconia-Based Fixed Dental Prostheses in a Period up to 10 Years: A Systematic Review

Keywords

Zirconia
Core Fracture
Survival
Fixed Dental Prosthesis
Systematic Review

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Received: 04.12.2017
Accepted: 26.01.2018

doi: 10.1922/EJPRD_01681Stefanescu08

ABSTRACT

Aims: The purpose of this study was to methodically review the literature concerning the success and survival rates of zirconia fixed dental prostheses (FDPs). Methods: A systematic search was conducted of MEDLINE, Elsevier and the Cochrane Library to identify relevant articles about zirconia FDPs. In order to obtain suitable articles, rigorous criteria were applied. The minimum follow-up period was five years. Results: From a total of 986 articles identified in the first electronic search, only 10 matched the inclusion criteria. A total of 368 patients with 430 zirconia FDPs were included in this systematic review. The survival rate was 89.43% ± 10.01% and chipping of the veneering ceramic occurred in 16.97% of the cases. Conclusion: Zirconia-based fixed dental prostheses perform reasonably well and can serve as an alternative to metal-ceramic fixed dental prostheses.

INTRODUCTION

Several factors such as poor oral hygiene or socio-economic circumstances cause many people to lose teeth, consequently dentists have many partially edentulous patients. If the patient's background or local conditions require a fixed dental prosthesis, clinical information and statistics about survival and long-term stability are needed. For many decades, porcelain-fused-to-metal has yielded great results for the fabrication of fixed dental prostheses (FDPs)[1] and good survival rates have been observed after more than 10 years of service.[2] This was considered a gold standard until practitioners started to think also about the long-term aesthetic results. Subsequently, strengthened ceramics were introduced instead of alloy infrastructures, but their indication was limited to frontal teeth or single crowns because of their mechanical properties.

Finally, when CAD-CAM technology was developed, yttrium partially stabilized tetragonal zirconia polycrystalline (Y-TZP) became the new material preferred by clinicians due to its improved mechanical properties, higher resistance to fracture and flexural strength of 900 - 1400 MPa. A particularly important feature is that its surface can suffer a stress-generated transformation from tetragonal to monoclinic phase when a crack occurs. The crack is sealed successfully and the fracture toughness is increased.[3] Zirconia's utility in dentistry spread from prosthetics to implantology, but its main application remained for crowns and FDPs. Frameworks made from Y-TZP provide great marginal fit[4] and lower occlusal wear of the antagonists in comparison with lithium disilicate or feldspathic porcelain.[5]

Nevertheless, the most common complication for zirconia FDPs is chipping of the veneering porcelain, and many studies have reported different rates for this, such as 10%,[6] 14.2%[7] or 0.8%[8] in a study made on a larger group of patients. Fracture rates of the framework have also been reported differently, with rates of 1.7%[8] or 4%.[9] Many criteria are considered for the evaluation of multi-unit FDPs with different lengths.

Because an assessment of the survival rates at five-year follow-up and more has to be made, a systematic review was performed to assess the fracture resistance and long-term stability of zirconia FDPs.

MATERIALS AND METHODS

SEARCH APPROACH

An electronic search was completed to select articles from MEDLINE (PubMed), Elsevier (Science Direct) and the Cochrane Library, published from January 1985 to April 2016. 'English language' and 'Humans' were set as filters for the following key words: zirconia AND FDP, zirconia AND FDPs, zirconia AND FPD, zirconia AND FPDs, zirconia AND multi-unit, zirconia AND fixed dental prosthesis, zirconia AND fixed dental prostheses, zirconia AND partial, zirconia AND bridge, zirconia AND span, zirconia AND framework, zirconia AND 3-unit, zirconia AND 4-unit, zirconia AND 5-unit, zirconia AND FDP AND clinical controlled trial, zirconia AND FDP AND randomized controlled trial, zirconia AND FDP AND PROSPECTIVE, zirconia AND FDP AND retrospective, zirconia AND FDP AND cohort, zirconia AND FDP AND longitudinal, zirconia AND FDP AND clinical. Only the Boolean operator AND was used. For this search, the following MeSH Terms were also used: zirconium AND dental prosthesis, zirconium AND fixed partial denture, zirconium AND bridge, zirconium AND randomized controlled trial, zirconium AND clinical controlled trial, zirconium AND adaptation, zirconium AND prosthesis failure. The search strategy is presented in Figure 1.

SELECTION CRITERIA

The assessment of potential articles was completed by two independent reviewers (CȘ, AP), who applied the following inclusion criteria:

1. Articles written in English
2. Studies performed on human subjects
3. Articles concerning multi-unit FDPs
4. Minimum five-year follow-up
5. Reported number of core fractures and survival rates

The excluded articles did not fulfill the inclusion criteria or were *in vitro* studies. Each article that met the inclusion criteria was analyzed and the following data was extracted: type of study, number of FDPs, number of patients, materials used, follow-up period, survival and success rates, complications, failures. Core fractures of the zirconia framework and minor/major chipping of the veneering ceramic were the main concern for this study.

QUALITY EVALUATION OF THE INCLUDED STUDIES

Two independent reviewers used the Newcastle-Ottawa scale to assess the quality of the selected studies and disagreements were resolved by discussion. Selection of the cohorts, comparability and the outcome of interest for cohort studies were the categories to be judged, and nine questions were addressed. For each question a star was given, so that the result for each article was between zero to nine stars. Those which obtained eight stars or higher were considered highly methodological qualitative studies, those within five to seven stars revealed medium quality, and those with a score of four or under expressed low quality. Given these points, a qualitative assessment of each study was realized.

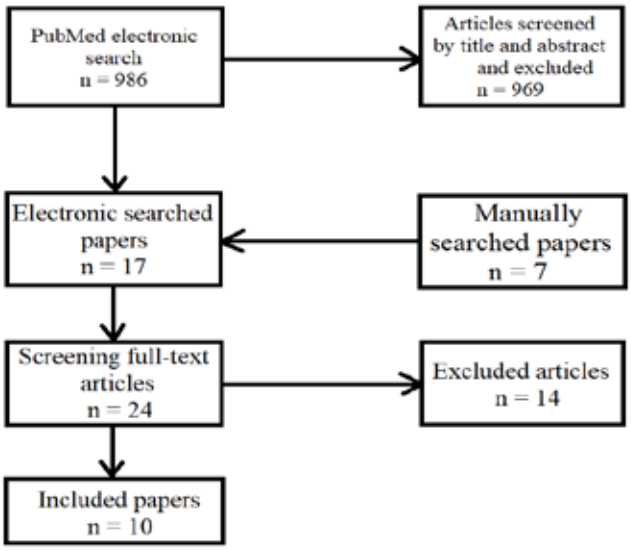

Figure 1: The search strategy

RESULTS

SYSTEMATIC REVIEW

From a total of 986 articles that were identified after the first electronic search, 17 were related to zirconia FDPs and another 7 were identified by manual search of articles in journals and reference lists. After 24 full-text articles were screened, the inclusion criteria were applied and only 10 studies matched. From these articles, 9 were prospective cohort studies and one was retrospective. There were no randomized controlled trials for a minimum five-year period that matched the inclusion criteria.

The methodologic quality of the studies was performed by using the Newcastle-Ottawa scale which is shown in Table 1. The score for 10 studies ranged from five to seven stars and only one study received four stars. None of the studies achieved a score of eight or nine stars. One[10] study scored seven stars, three[9,11,12] studies scored six stars and five studies[13-17] scored five stars, revealing a moderate quality. The mean overall score for the 10 studies including the one with four stars was 5.4 ± 0.84. Fourteen studies were excluded from this systematic review and Table 2 shows the reasons for exclusion.

Six of the included articles [9,10,12,13,15,16] had a five-year follow-up, one[11] had a six-year follow-up, one[14] had a seven-year follow-up, one[17] had nine-year follow-up and one[18] had a 10-year follow-up. The mean of the follow-up was 6.2 ± 1.87 years for the 10 articles included in the systematic review. All the included articles comprised 430 FDPs. Seven of 10 studies provided data about the exact number of units. Information from these studies showed that at least 250 of 430 FDPs were three-unit (58%), at least 33 FDPs were four-unit (7%), at least five FDPs were five-unit and the other 142 FDPs were prostheses with three to seven units (33%). The articles which matched the inclusion criteria are listed in Table 3 by main author, details about the FDPs and brands of materials used.

Technical and biological complications were the main concern regarding zirconia-based FDPs. As other studies point out, the most encountered technical complication is the chipping of the veneering ceramic. Two types of chipping can be observed: cohesive, which is a fracture without exposure of the framework, and adhesive, which means a fracture of the veneering ceramic with exposure of the framework.[19] This adhesive type of fracture can cause the failure of the FDP but it can also be repaired by the clinician. Thus, a major chipping can either be a failure or a complication. One[14] of the studies reported major chipping as

Table 1. Quality assessment of the included studies using the Newcastle-Ottawa scale

Reference	Intervention cohort representative	Non-intervention cohort selection	Ascertainment of exposure	Outcome interest negative at start	By design	By analysis	Outcome assessment	Follow-up period	Follow-up adequacy	Score
Burke *et al.*[16]	NO	NO	YES	YES	NO	YES	YES	YES	NO	5
Håff *et al.*[17]	NO	NO	YES	NO	YES	YES	YES	YES	NO	5
Lops *et al.*[11]	NO	NO	YES	NO	YES	YES	YES	YES	YES	6
Molin *et al.*[15]	NO	NO	YES	NO	NO	YES	YES	YES	YES	5
Raigrodski *et al.*[12]	NO	NO	YES	NO	YES	YES	YES	YES	YES	6
Rinke *et al.*[14]	NO	NO	YES	NO	YES	YES	YES	YES	NO	5
Sax *et al.*[18]	NO	NO	YES	NO	NO	YES	YES	YES	NO	4
Schmitt *et al.*[9]	NO	NO	YES	YES	NO	YES	YES	YES	YES	6
Schmitter *et al.*[13]	NO	NO	YES	NO	YES	YES	YES	YES	NO	5
Sorrentino *et al.*[10]	NO	NO	YES	YES	YES	YES	YES	YES	YES	7

a failure and the rest reported it as a complication because it could be treated with composite and did not impair the function of the FDP. Minor chipping of the veneering ceramic could be observed in 61 FDPs (14%), while major chipping was found in only 12 (2%). Other technical complications were represented by poor marginal adaptation, loss of retention and discoloration of the veneering ceramic with a total of 22 cases (5%). Biological complications were recorded for 19 FDPs (4%) and were related to endodontic complications, secondary caries and periodontal problems.

The most encountered failures were surprisingly not the technical ones (i.e. core fractures), but the biological ones. Twenty-three FDPs (5%) failed because of biological complications and the most frequent cause was secondary caries. In addition to chipping fracture of the veneering ceramic, an important concern of the clinicians is the fracture of the zirconia core. The studies reported that this happened in 13 cases (3%).

DISCUSSION

Because strict inclusion criteria were applied, no RCT matched the minimum five-year follow-up criterion. In the absence of RCTs, only prospective and retrospective cohort studies were included in this systematic review to assess the success and survival rates of zirconia-based FDPs. According to Anusavice *et al.*,[20] survival for FDP was described as a restoration that remained in service until follow-up, with complications that did not impair its functionality as chipping fracture, and success was defined as a restoration free of any complication at the follow-up. From the total of 10 studies included for the systematic review, only seven[10-15,17] provided information about success rates.

Two studies[12,16] reported that the zirconia blanks used were produced by Lava, in another two studies[15,17] blanks from Denzir were used. In addition, zirconia blanks from DeguDent[13,14] and Procera[10] were used. The three remaining articles did not mention any information about the material used for zirconia frameworks. Several types of luting systems were also used. RelyX (3M ESPE) was used in three studies,[10,12,16] Ketac Cem (3M ESPE) was also used in two studies,[9,13] Panavia F and Panavia[21] (Kuraray) were used in two studies[15,18] and one study[14] used luting system from Harvard Dental. Variolink from Ivoclar Vivadent was used for luting FDPs in a study[18] that also used Panavia (Kuraray).[21] From the total of 10 articles, only six provided information about the connector dimensions. The majority of the studies[9,10,12,14] used a connector sized 9 mm^2 or above, but with an unspecified precise dimension. In two studies[13,16] FDPs were placed with a precise connector dimension of 9 mm^2.

Table 2. Reasons for exclusion

Reference	Follow-up period < 5 y	Screw retained FDPs	Multiple publications on the same cohort of patients	Insufficient data	Other types of zirconia
Borelli *et al.*[23]				*	
Chaar *et al.*[24]					*
Eschbach *et al.*[25]			*		
Ioannidis *et al.*[26]					*
Kern *et al.*[27]					*
Koenig *et al.*[28]	*				
Kolgeci *et al.*[29]	*				
Larsson *et al.*[30]		*			
Larsson *et al.*[31]		*			
Larsson *et al.*[32]	*	*			
Le *et al.*[33]		*			
Monaco *et al.*[34]		*			
Pihlaja *et al.*[8]	*				
Raigrodski *et al.*[35]	*				

Table 3. Characteristics of the included studies

Reference	Location	Study type	No. of patients	FDPs	FDPs at follow-up	No. of units	Connector width	Luting system	Type of zirconia	Dropouts
Burke *et al.*[16]	UK General Dental Practices	Observational study	36	41	33	3-unit (n = 38); 4-unit (n = 3)	9 mm²	RelyX Unicem (3M ESPE)	Lava Y-TZP	8
Håff *et al.*[17]	National Dental Health Service and private practices	Retrospective study	56	58	32	3-unit (n = 22); 4-unit (n = 4); 5-unit (n = 5); 6-unit (n = 2)	NR	Resin composite and glass-ionomer cement	Denzir HIPed Y-TZP	26
Lops *et al.*[11]	University of Milan, Italy	Prospective study	28	28	24	NR	NR	NR	NR	4
Molin *et al.*[15]	NR	Prospective study	18	19	19	All 3-unit	NR	De Trey Zinc (Dentsply) and Panavia F	HIPed Y-TZP (Denzir)	0
Raigrodski *et al.*[12]	NR	Cohort clinical study	16	20	18	All 3-unit	≥ 9 mm²	RelyX (3M ESPE)	Lava	2
Rinke *et al.*[14]	University of Goettingen, Germany	Prospective study	75	99	80	3-unit (n = 81); 4-unit (n = 18)	≥ 9 mm²	Harvard, Richter & Hoffmann (Harvard Dental)	Cercon Base, Degu Dent	19
Sax *et al.*[18]	NR	Prospective study	45	57	26	3, 4 and 5 -unit	NR	Variolink (Ivoclar) or Panavia 21 (Kuraray)	NR	31
Schmitt *et al.*[9]	Friedrich-Alexander University, Erlangen, Germany	Prospective study	30	30	25	3-unit (n = 22); 4-unit (n = 8)	≥ 9 mm²	Ketac Cem (3M ESPE)	Presintered yttria-stabilized zirconia blanks	5
Schmitter *et al.*[13]	University of Heidelberg	Prospective study	27	30	22	4, 5, 6, 7 -unit	9 mm²	Ketac Cem (3M ESPE)	Presintered zirconia blanks (Degu Dent)	8
Sorrentino *et al.*[10]	"Federico II" University of Naples, Italy	Prospective study	37	48	48	All 3-unit	≥ 9 mm²	RelyX Unicem (3M ESPE)	Presintered zirconia blanks (Procera)	0

Table 4. Data regarding follow-up, complications, survival and success rates

Reference	Follow-up	Core fracture	Chipping Minor / Major		Other technical complications	Biological complications	Biological failures	Survival rate	Success rate
Burke *et al.*[16]	5 years	0	7	1	4	2	0	97%	NR
Håff *et al.*[17]	9 years	2	1	2	1	7	2	94%	73%
Lops *et al.*[11]	6 years	1	1	NR	2	NR	1	88.9%	81.8%
Molin *et al.*[15]	5 years	0	0	0	1	0	0	100%	95%
Raigrodski *et al.*[12]	5 years	0	2	2	1	1	1	90%	79%
Rinke *et al.*[14]	7 years	4	19	4	8	5	6	83.4%	57.9%
Sax *et al.*[18]	10 years	3	16	0	0	1	12	67%	NR
Schmitt *et al.*[9]	5 years	1	4	2	1	2	0	92%	NR
Schmitter *et al.*[13]	5 years	2	8	1	4	1	1	82%	27.3%
Sorrentino *et al.*[10]	5 years	0	3	0	0	0	0	100%	91.9%

The minimum survival rate reported for the zirconia-based FDPs was 67% in a 10-year study, in contrast with the maximum survival rate which was 100% in two studies.[10,15] The overall survival rate was 89.43% ± 10.01%. Only seven,[10-15,17] of 10 studies reported success rates and the overall was 72.27% ± 23.33%. The lowest success rate was 27.3%,[13] whereas the highest was 91.9%,[10] both recorded for five-year studies.

If only the studies with 5-year follow-up[9,10,12,13,15,16] are regarded, the overall survival rate is 93.5% ± 6.97%. Only four[10,12,13,15] of these 5-year studies report success rates and the overall is 73.3% ± 31.43%.

In a systematic review, Heintze *et al.*,[21] evaluated 12 studies with 595 zirconia-based FDPs and stated that veneer chippings were recorded in 24% of the cases, while in the present paper an 16.97% rate of chipping was recorded. No significant difference could be observed either in the case of survival rates, which were 90% for zirconia FDPs, in comparison with 89.43 ± 10.01% in the present paper. It should be mentioned that Heintze *et al.*, evaluated articles with a mean follow-up of three years.

Pjetursson *et al.*,[1] detected a five-year survival rate of 90.4% for zirconia FDPs and a 14.5% rate of chipping. In addition, the five-year failure rate because of the core fracture was 1.9%, which contrasted with the present review with 3%. In a study over a three- to five-year period, Agustin-Panadero *et al.*,[19] encountered a lower rate of chipping that ranged between 6% and 15%.

Schley *et al.*,[22] estimated a five-year survival rate of 94.29% in a systematic review based on 330 zirconia FDPs. Chipping of the veneering ceramic was encountered in 20.56% of the cases, in comparison with 16.97% in the present study.

When compared to metal-ceramic, zirconia FDPs seem to show weaker results. Pjetursson *et al.*,[1] assessed 40 studies that comprised 1796 metal-ceramic FDPs and found a survival rate of 94.4%. Nevertheless, they did not observe any statistical significance in difference between zirconia and metal-ceramic FDPs. In the same systematic review mentioned above, Heintze *et al.*,[21] encountered a survival rate of 97% for 134 metal-ceramic FDPs.

One limit of the present systematic review is the deficiency of clinical studies with a follow-up longer than five years. Another limitation is the lack of data about success rates in the existing studies.

CONCLUSIONS

Within the limits of this systematic review, the following conclusions can be drawn:

- Survival and chipping rates encountered are equivalent to those observed for zirconia FDPs in previous reviews conducted over time intervals of less than 5 years. This suggest that zirconia FDPs retains its properties over time.

- Survival rates encountered are lower but comparable to those observed in previous reviews of metal-ceramic FDPs. This suggest that metal-ceramic FDPs can be replaced by zirconia FDPs, which can be considered a predictable option.
- The most encountered failures are the biological ones, rather than core fractures of the zirconia frameworks.
- The most encountered complication is the chipping fracture of the veneering ceramic which can occur more frequently than all other complications together.

ACKNOWLEDGMENTS

The authors appreciate the help of Mr Adrian Dușa, PhD, Professor at the Department of Sociology and Social Work, University of Bucharest, with the statistical analysis. The authors report no conflicts of interest related to this study. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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