

Research Article

A Systematic Review of Survival and Complications of Posterior Zirconia Based Fixed Dental Prostheses with a Minimum Follow-Up Time of 3 Years

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Abstract

Purpose: To assess the survival rates and incidences of complications of posterior zirconia based fixed dental prostheses.

Material and Methods: An electronic literature search of Medline (PubMed) was conducted independently by three reviewers to identify clinical studies from 2006 to 2016 and was completed by a manual search. Key words, inclusion and exclusion criteria were well defined.

Results: The search revealed 419 titles and led to the final analysis of 19 full text articles, 11 studies met the inclusion criteria, one was a randomized clinical study with 3 years follow up results. The others were cohort prospective studies. Technical complications included chipping of veneering porcelain which was the most frequent complication. However, biological complications, included: secondary caries, abutment fracture and marginal discoloration. The survival rates of zirconia based short unit FDPs are promising, and for FDPs with long span, further randomized controlled clinical trials are necessary. An important improvement of the veneering system is required.

Conclusion: Short and long term clinical data suggest that posterior zirconia based fixed dental prosthesis may serve as an alternative to metal ceramic fixed dental prostheses in the posterior dentition.

Keywords: All Ceramic; Complication; Fixed Dental Prostheses; Posterior; Span Length; Success; Survival Rate; Systematic Review; Zirconia

Introduction

Several meta-analyses have demonstrated good long term clinical results for conventional fixed dental prosthesis with a metal framework [1-5]. However, the gray metal framework made the imitation of natural esthetics difficult; the demand for free metal materials has arisen [6]. This has led to development of several different ceramics that are esthetically pleasing and biocompatible [7,8]. Due to their low mechanical stability, all ceramic systems (feldspathic-glass and glass-reinforced-ceramics) only seem suitable for single crowns [9,10]. More recently, high-strength ceram-

ics have been developed for reconstructive dentistry. Zirconia, has the best mechanical properties of all previously introduced ceramics [11,12]. Laboratory studies indicated that zirconia frameworks might have favorable mechanical properties to withstand the occlusal forces both in anterior and in posterior regions [13]. Hence, zirconia has proposed as an alternative to metal for the fabrication of FDP frameworks and in cases of multiple-tooth gaps [14]. Systematic reviews of the literature on zirconia-based FDPs confirmed the excellent overall clinical performance of FDPs with zirconia frameworks [5,12]. In fact, no differences of the survival rates of FDPs with zirconia and metal frameworks were found in numerous studies [5,15,16]. The estimated 5-year survival rate of posterior zirconia FDPs was 94.24% [5]. Two limitations have been observed clinically as related to the bond strength of the ve-

neering porcelain to the zirconia framework. These are veneering porcelain chipping and the possible degradation of zirconia when exposed to moisture in the oral environment [17]. Hence, clinical long term studies are needed to test the outcome of zirconia over time.

The purpose of this systematic review was to evaluate the short- and long-term survival rate of based FDPs, to identify the incidence of technical and biological complications and to provide recommendations for the clinical use of posterior zirconia based FDPs.

Material and Methods

An electronic literature search of the database MEDLINE (PubMed), from January 2006 to December 2016, searching publications in English language by using the following key and Mesh terms terms fixed partial denture' (Mesh), OR 'Partial fixed denture'(Mesh), OR 'FDP'(all fields)OR 'FDPS'.OR 'posterior fixed partial denture' (all field), OR 'bridge'(all fields)AND 'zirconia', OR 'zirconium' AND, 'all-ceramics' AND' Survival', OR 'survival rate' OR 'prosthesis failure' OR 'prognosis'.

All titles revealed by this research were screened, and an abstract search to conduct articles that could be of possible relevance was done. Additional hand searching was done to identify any other clinical studies on zirconia FDPs. Out of the included abstracts, full-text articles were chosen. The reviewers resolved, by discussion, any disagreements concerning the assortment of articles.

Inclusion Criteria

The additional inclusion criteria for study selection were: Studies with a minimum mean follow-up period of 3 years

Prospective Studies

- Studies had to include and follow-up at least 10 patients.
- Subjects of studies had been examined clinically at regular intervals.
- Studies on posterior multiple coverage units, fixed prostheses fabricated entirely from zirconia frameworks were considered.
- Data on the survival and failure of the FDPs and descriptions of the biological and technical complications had to be reported.

Exclusion Criteria

The following study types were excluded

- In vitro or animal or retrospective studies.
- studies with less than 3 years of follow up.
- Studies on partial coverage prostheses or implant-supported restorations were also excluded.

Data Extraction

Data on the following parameters were extracted: author(s), year of publication, ceramic system, veneering system, total number of FDPs, reported mean follow-up time, published FDP survival rate, number of FDPs lost, reported biological complication (caries, periodontal diseases, root fracture), reported technical complication (framework fracture, minor chipping, major chipping, loss of retention).

Statistical Analysis

Survival was defined as the FDP remaining in situ with or without modification for the observation period. Failures included every type of complication that led to the removal of a restoration.

For each study, event rates were calculated by dividing the number of failures or complications by the total exposure time. The total exposure was determined by multiplying the total number of FDPs by the mean follow-up time, no more precise information. For further analysis, the total number of events was considered to be Poisson disturbed for a given sum of FDP exposure years and Poisson regression with a logarithm link-function and total exposure time per study as an offset were used. Robust standard errors were calculated to obtain 95% confidence intervals of the summary estimates of the event rates [18,19]. All analyses were performed using Stata, version 13.1.

Results

The electronic search revealed 419 titles that for the above-mentioned search terms. Of these 419 titles; 11 clinical studies were selected. Of the clinical studies identified, there were 10 prospective cohort studies [16,20-28], only one randomized controlled trial [15], evaluating 3 to 10-year follow-up of restorations with zirconia frameworks. The articles included in this systematic review are listed in table I by author, brand of restoration Connector dimensions, and veneering technique. The 11 clinical studies included one 10-year follow-ups [16], two 7-year follow-ups [27,28], three 5-year follow-ups [21,24,25], three 4-year follow-ups [15,23,26] and two 3-year follow-ups [20,22].

In all included studies, preparation guidelines according to the manufacturer's recommendation were considered. Different measurement methods were used to examine the FDPs at the recall appointments in order to identify the technical and biological complications. In five [21,23,26,27,28] studies remarkable complications of FDPs were discovered and the criteria used were not specified.

In two studies [22,25] the California Dental Association (CDA) quality evaluation criteria, in two studies [20,24], Modified Ryge criteria, in two studies, the United States Public Health Service (USPHS) were used to judge the FDPs [15,16]. Survival rates of 423 FDPs ranged from 67% to 100%, resulting in a mean

5-years survival rate of 84.35%, which were predominantly posterior 3-unit reconstructions for all FDPs examined.

Technical Complications

The incidences and complications-free rates concerning technical complications and failures are shown in. The most prevalent technical complication was chipping of the veneering porcelain. Followed by loss of retention, framework retention, marginal discrepancies.

Chipping

According to the study of Sax et al. [16], chipping/fracture of the veneering ceramic was detected in 16 FDPs over 10 years (complication rate 32%). A significant correlation of the span of the FDPs and the incidence of chipping was observed; 4- and 5-unit FDPs had a 4.9 times higher probability for chipping than 3-unit FDPs. The study of Roedger, et al. [23] showed that chipping of the veneering material was observed in 9 restorations in the experimental group and 4 specimens in the Ceram-S group. The majority of veneering material events were minor chippings. The probability for success of the ceramic veneers was 91.6% in the experimental group and 88% in the Ceram-S group after 48 months.

Loss of Retention

Five studies provided details on loss of cementation [21,23-25,28]. According to Roedger, et al. [23], from 99 posterior FDPs, 6 losses of retention and could either be cemented, only one decementation from 25 posterior FDP during 5 years, had been reported by [25] and [28] observed that four out of 80 conventionally cemented lost their retention and could not be recemented, 4 FDPs could either be cemented.

Framework Fractures

Information on the occurrence of framework fractures was given in seven studies [16,21-23,25,26,28]. Only one, two, three or four framework fractures were reported, in one case a 5-unit FDP fractured in the connector area [21] due to occlusal trauma. For Schmitt, et al. [25], one framework fracture after 54 months. According to Sax, et al. [16], three framework fractures led to the replacement of the FDP after ten years. Rinke, et al. [28] observed four framework fractures during seven years of study.

Marginal Discrepancies

Three studies [15,16,24,27] described marginal discrepancies that were detected during follow-up. The randomized controlled trial of [15] showed that, the marginal adaptation was judged clinically acceptable in 16.7% according to USPHS criteria, compared to 6.5% of the metal ceramic FDPs. Sax, et al. [16] reported that the marginal degradation (USPHS rating B or C) was found in 39 FDPs during the 10 years of observation. The 10-year complication rate for marginal discrepancy was 90.7%. No influ-

ence of the number of FDPs units on the marginal adaptation was found. However, this complication was found more frequently the longer the clinical service time was ($p < 0.001$, multiple mixed effects regression models). Only one FDP rated Bravo for a slight marginal discrepancy for [24].

Biological Complications

- Loss of abutment tooth vitality, abutment tooth fracture, periodontal diseases and secondary caries were the predominantly reported as biologic complications for posterior zirconia FDPs. The complication free rates and incidences of biological complications and failures are presented in.
- Secondary caries- Five investigations reported details on secondary caries, [16,21,23,24,28]. For Rinke, et al [28]. Three cases of progressed marginal caries resulted in the removal of the FDPs and were accordingly judged as failure, the other four lesions were supplied with composite and the reconstructions remained *in situ*; Sax, et al. observed 11 cases of secondary caries after ten years of study. No secondary caries was observed by [25] and [26].
- Endodontic complications- All trials reported endodontic complications, altogether twenty-five cases. Raigrodski, et al. [24] observed, five abutments became non-vital, seven with post-operative sensitivity, one irreversible pulpitis. For Sax, et al. two apical ostitis.
- Fracture of abutment teeth- Only three studies [16,24,28] observed, five cases of fracture of abutment teeth, in two studies a root fracture was considered as a catastrophic failure [16,24].

About periodontal diseases, the majority of studies, reported that there is no significant difference of the periodontal parameters: PCR, PPD and BOP were found between test and control teeth. Only Schmitt, et al. [22] found a significant difference, they discovered significantly more plaque on distal reference teeth at the 12- and 24-month recall appointments.

Discussion

This systematic review focused in the results of prospective clinical studies on posterior based FDPs. The objective of this review was to summarize the available information about survival rates, their frequent biological and technical complications, in order to evaluate the clinical performance of these type of reconstructions, and if possible to derive recommendation for clinical use. A mean follow-up period of at least 3 years was a necessary compromise. Comparing the present review to the systematic review of 2010 [5], six new studies on posterior zirconia FDPs were added [16,24-28], and focused only on posterior FDPs with an important follow-up period of 7 and 10 years.

The results of the present review, hence, may be considered

more robust with more impact for the daily clinical practice, within the limits of the study; the number of published studies was limited because of the relatively short time zirconia has been used in dentistry. The sample size within most of the studies was relatively low. Lack of similar outcome criteria and time periods made it difficult to draw definitive conclusions. Only one study was a randomized controlled trial with clinical significance [16]. Criteria from study to study as what constituted a failure varied, so combining results for statistics was not easy.

The overall survival rate for posterior zirconia based FDPs was 84% after a mean follow period of 5 year(95% CI). This result is comparable to the estimated survival rate of Schley et al. after 5yr [5]; 94.29% and the estimated 5-year survival rate of metal ceramic FDPs;93.8%.reported by [15]. The rate of complete failures resulting from framework fracture or loss of retention was very low, this major technical complication could be explained by under-reduced tooth structure and insufficient connector size, An important study of [13] based on the evaluation of some fatigue parameters after the restoration, found that posterior zirconia FDPs may exhibit a good long-term prognosis if connectors are properly designed and fabricated with at least 5,7mm², 12,6mm² and 18,8mm² for the fabrication of a 3, 4 and 5 Unit FDP respectively.

One important technical complication reported by several studies was the marginal discrepancies [15,16, 24,27]. These problems were most likely associated with the insufficient accuracy of the prototype CAM system. Numerous investigations show that these initial problems have since been overcome. The CAD/CAM systems of today have improved with respect to precision. Several studies proved that the accuracy of current of CAD/CAM reconstructions is clinically acceptable. Furthermore, CAD/CAM techniques exhibit an accuracy similar to that of traditional metal-ceramic prostheses [16,29].

Rinke, et al. [28] showed that the span length of the FDP had an effect on the fit of zirconia substructure, which is fabricated using CAD/CAM technique especially at the occlusal area. The increase of span length of zirconia framework of 6 or more unit FDP, may decrease the marginal and internal fit. These findings were comparable to those of [30]. In one other study, the problems with fit were associated with a high occurrence of secondary caries, leading to the loss of the FDP in some of cases [21]. The possible other explanation for the misfit should be discussed.

The most frequent technical complication was the fracture of the veneering ceramics [15,16,20-28]. The high incidence of chipping may be due to the thermal compatibility of the veneering ceramics and the zirconia frameworks [16,25,26,28]. The flexural strength of the veneering ceramics, different surface treatments of

the frameworks and the bond strength between veneering ceramic and zirconia frameworks [31]. In the RCT and interesting clinically relevant observation has been made. It appeared that roughness of the veneering ceramic due to occlusal function or grinding was associated with the shipping. Hence meticulous polishing of the rough surfaces is crucial [15].

In fact, the design of the framework should be properly respected. On the one hand the design of the connectors of posterior FDPs have to be adequate, on the other hand space for an even thickness of the veneering ceramic need to be provided [31]. Bueuer, et al. reported on a high strength computer-aided design CAD/CAM-fabricated veneering material with a higher fracture load when compared with conventional veneering techniques [32]. This indicates the using this high-strength ceramic veneering system instead of conventional veneering techniques may reduce the incidence of chipping. The use, also of monolithic zirconia with no veneering porcelain has increased and the risk for the fractures has diminished [33].

The biological of posterior zirconia-based FDPs generally was favorable in all studies. Especially in terms of periodontal health, several studies reported; any difference or changes in the biological health of the soft and hard tissue [15,16,20,21,24-28]. However, [34] and [35] in a 3-year follow-up studies, found that abutment teeth tended to have increased pocket depths. Ortorp, et al. [17] reported that only 4 of 25 crowns were free from gingival bleeding and calculus.

Whereas, regarding favorable periodontal health, zirconia has been proved in terms of biocompatibility as having the best properties [36,37]. In fact, zirconia biocompatibility had been studied in vivo as well as in vitro, no adverse response was reported following the insertion of ZrO₂ samples to bone or muscle. In vitro experimentation showed absence of mutations and good viability of cells cultured on this material. Newly proposed zirconia implants seem to have good biological and mechanical properties [36].

In conclusion, within the limits of this investigation, the promising survival rate of zirconia framework indicates this type of ceramic to be a valid alternative for metal frameworks. Short and medium-span posterior zirconia frame work are stable. Higher rates of clinical complications, however, have to be taken into consideration. It is clear that longer observation periods are required in order to validate these long terms results. Especially for clinical long term success, the veneering materials, therefore, need to be refined. Shortcomings of the marginal accuracy of zirconia reconstructions will be overcome by further refinements of the computerized production technologies in future. More studies are needed concerning the survival probability of long 'span FDPs and FDPs with a cantilever design.

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