Survival of Zirconia- and Metal-Supported Fixed Dental Prostheses: A Systematic Review

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Purpose: The aim of this review was to systematically evaluate and compare the frequency of veneer chipping and core fracture of zirconia fixed dental prostheses (FDPs) and porcelain-fused-to-metal (PFM) FDPs and determine possible influencing factors. ***Materials and Methods:*** The SCOPUS database and International Association of Dental Research abstracts were searched for clinical studies involving zirconia and PFM FDPs. Furthermore, studies that were integrated into systematic reviews on PFM FDPs were also evaluated. The principle investigators of any clinical studies on zirconia FDPs were contacted to provide additional information. Based on the available information for each FDP, a data file was constructed. Veneer chipping was divided into three grades (grade 1 = polishing, grade 2 = repair, grade 3 = replacement). To assess the frequency of veneer chipping and possible influencing factors, a piecewise exponential model was used to adjust for a study effect. ***Results:*** None of the studies on PFM FDPs (reviews and additional searching) sufficiently satisfied the criteria of this review to be included. Thirteen clinical studies on zirconia FDPs and two studies that investigated both zirconia and PFM FDPs were identified. These studies involved 664 zirconia and 134 PFM FDPs at baseline. Follow-up data were available for 595 zirconia and 127 PFM FDPs. The mean observation period was approximately 3 years for both groups. The frequency of core fracture was less than 1% in the zirconia group and 0% in the PFM group. When all studies were included, 142 veneer chippings were recorded for zirconia FDPs (24%) and 43 for PFM FDPs (34%). However, the studies differed extensively with regard to veneer chipping of zirconia: 85% of all chippings occurred in 4 studies, and 43% of all chippings included zirconia FDPs. If only studies that evaluated both types of core materials were included, the frequency of chipping was 54% for the zirconia-supported FDPs and 34% for PFM FDPs. When adjusting the survival rate for the study effect, the difference between zirconia and PFM FDPs was statistically significant for all grades of chippings ($P = .001$), as well as for chipping grade 3 ($P = .02$). If all grades of veneer chippings were taken into account, the survival of PFM FDPs was 97%, while the survival rate of the zirconia FDPs was 90% after 3 years for a typical study. For both PFM and zirconia FDPs, the frequency of grades 1 and 2 veneer chippings was considerably higher than grade 3. Veneer chipping was significantly less frequent in pressed materials than in hand-layered materials, both for zirconia and PFM FDPs ($P = .04$). ***Conclusions:*** Since the frequency of veneer chipping was significantly higher in the zirconia FDPs than PFM FDPs, and as refined processing procedures have started to yield better results in the laboratory, new clinical studies with these new procedures must confirm whether the frequency of veneer chipping can be reduced to the level of PFM. *Int J Prosthodont 2010;23:493–502.*

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In prosthetic dentistry, there is a growing tendency toward replacing metal-based restorations with all-ceramic ones. Single crowns composed of different materials (lithium disilicate, leucite, aluminium oxide) have been successfully placed for 10 to 20 years. They have been shown to achieve good clinical survival rates and have thus become the standard of care for single crowns, especially in the anterior region.[1,2]

For fixed dental prostheses (FDPs), zirconia-based material combinations have been propagated since the turn of the century. Zirconia is a white opaque material with high strength.[3] Zirconia is milled using computer-aided design/computer-assisted manufacturing devices and veneered with feldpathic/fluorapatite ceramic either manually or via the lost-wax and press technique.

Metal-ceramic restorations, also known as porcelain-fused-to-metal (PFM) restorations, are considered the gold standard in fixed prosthodontics. All new materials used as an alternative have to be as good as metal-ceramic, particularly with regard to veneer chipping, core fracture, and marginal fit.

Some clinical studies with data up to 5 years reported a high prevalence of chipping of the ceramic veneering material for zirconia-supported FDPs.[4–6] Fracture of the framework, however, has been rarely reported to date. The prevalence of veneer chipping seems to be higher when the data are compared to that for metal-supported FDPs.[7] A recent systematic review, which evaluated PFM versus all-ceramic FDPs, concluded that chipping of all-ceramic restorations was significantly higher in all-ceramic FDPs than in PFM FDPs.[8] This review, however, included only three studies on zirconia. Since an increasing number of clinicians are incorporating zirconia-based FDPs into their practice, it is time to systematically review all available clinical evidence on zirconia- versus metal-based FDPs by applying the same clinical parameters to all data.

Possible influencing factors, such as the type of veneer material, the number of units, or the location in the mouth, were included in the present evaluation. Other questions to be considered in the review were whether the variation in the technical fabrication of the FDPs, such as support of cusps (yes/no), veneer thickness, or sandblasting of the core prior to cementation, had an influence on the prevalence of veneer chipping. Laboratory data suggest that restorations are more prone to chipping if the thickness of the veneer is inappropriate in relation to the core thickness and if the veneer material in the cusp area is unsupported by the core.[9,10] Sandblasting of zirconia can weaken the core material by inducing cracks.[11]

The following hypotheses were formulated: (1) zirconia-based FDPs exhibit more chipping of the veneer than metal-based FDPs, (2) the frequency of chipping is independent of the veneer material, (3) the frequency of chipping is higher in FDPs with more than three units compared to three-unit FDPs, and (4) the frequency of chipping is higher in FDPs with unsupported cusps.

Materials and Methods

Systematic reviews on PFM FDPs were included in this study. Furthermore, the medical/dental database provided by PubMed and the SCOPUS scientific abstract and citation database, as well as published abstracts from the International Association of Dental Research (IADR), were searched for clinical studies on zirconia- and metal-supported FDPs. Search terms included “zirconia,” “PFM” (or “metal ceramic”), and “clinical.” The search was conducted in March 2009. The principle investigators of any clinical studies on zirconia FDPs were contacted to provide additional information.

Included studies must have been prospective clinical trials of at least 2 years and report on dropouts, technical failures (ie, fracture of the framework or chipping of the veneer material and its extent per recall interval) and debonding, and replacement of FDPs due to fracture or chipping. Biologic reasons for failure such as endodontic treatment and periodontal inflammation were not taken into account.

An attempt was made to retrieve the following data from the publications regarding each FDP: number of units, type of tooth replaced (molar, premolar, canine, or anterior tooth), location in the mouth (maxilla or mandible), time of technical event and type (core fracture, chipping of veneer, or debonding), and last recall.

Grading of Veneer Chipping

Since all studies reported on the technical failures in detail, a chipping grading scale comprising three grades was established according to the treatment that followed the chipping: grade 1 = small veneer chipping that received no further treatment except polishing, grade 2 = moderate veneer chipping that was repaired with composite, and grade 3 = severe chipping that led to replacement of the entire FDP. If the chipping grade changed during the observation period, the most severe grade was included in the data set.

Statistical Analysis

Based on the available information, a file containing data on each FDP in each study was established. This file included information on the technical characteristics of the FDP (zirconia or PFM, layered or pressed, number of units, etc), the time of the event, and the type of event encountered. Since the time of the event (respectively, the follow-up time for those subjects without an event) was only known approximately, classical approaches for survival data (eg, Kaplan-Meier or Cox regression) were not indicated. Instead, a model assuming five different constant rates (before 1 year, between 1 and 2 years, between 2 and 3 years, between 3 and 4 years, and after 4 years) was used. Such a model is termed "piecewise exponential," since it is a generalization of an exponential model where the rate is assumed to be constant across the entire period considered. Similar to an exponential model, a piecewise exponential model can be fit using Poisson regression with an offset after the data have been reorganized appropriately.12 Importantly, a fixed study effect was able to be included in this piecewise exponential model, in addition to the effect of the factor of interest, which disentangled both effects. This was, however, not possible for the factors "veneer material," "veneer thickness," "support," and "sandblasting," which were too confounded with the study factor. Survival curves estimated from piecewise exponential models with a study effect are different for each study. To illustrate the effect of a factor of interest, a survival curve for a typical study is plotted. All models were calculated using the free *R* software (R Foundation for Statistical Computing).

To evaluate whether a specific veneering material caused more chippings than another, studies that evaluated more than 50 FDPs for one specific veneering material were pooled.

Results

Studies

Two meta-analyses[13,14] and one systematic review[7] were identified for metal-based FDPs. An updated article was published 2 years later by the same research group as the systematic review.[15] In the same year, that research group used similar data on PFM FDPs and compared them to all-ceramic FDPs.[8] None of the studies included in these reviews fulfilled the inclusion criteria. The main shortcomings were: retrospective studies, no report on dropouts, no systematic recalls, no specification on the type of FDP, and no detailed description of technical failures.

The additional search using the databases revealed one study that fulfilled the inclusion criteria.[16] In this 6-year, prospective, randomized controlled study, porcelain-fused-to-titanium restorations were compared to porcelain-fused-to–gold alloy. However, since only 25 FDPs were recalled in the control group and half of them were cantilever FDPs, this study was not included in the review.

The search for prospective trials on zirconia-based FDPs revealed 13 studies: 12 on natural teeth and 1 on implants. Zirconia-based FDPs were directly compared with metal-based FDPs in randomized controlled clinical trials by two research groups.[6,17,18] In the studies by Christensen et al,[6,18] five different zirconia-supported systems were compared with three metal-supported systems with 32 or 33 FDPs per system. The systems were placed by 116 general practitioners; for each system, two laboratories were chosen by the material's manufacturer to guarantee proper fabrication of the FDPs. The data in these studies on PFM restorations were used for the comparison with zirconia-based FDPs. Table 1 lists the study characteristics and materials used in all studies included. Six principle investigators of clinical trials provided additional information on their clinical trials and two provided manuscripts not yet published in journals.

Results of the studies by Christensen et al[6,18] were only published in IADR abstracts, where only a cumulative number of chippings were reported for each zirconia or metal-supported system. The following data were retrievable from the abstracts: number of FDPs, number of dropouts, number of core fractures, number of FDPs without defects, and number of replaced FDPs. The number of replaced FDPs minus the number of FDPs with core fractures resulted in the number of FDPs that were replaced due to major chippings (grade 3). However, the number of FDPs with defects other than grade 3 also included FDPs with surface degradation and cracks.

Study Populations

Ten studies reported on the mean age of the subjects and 11 on the distribution of women and men. The mean age of the subjects based on 10 studies was 48.3 ± 5.8 years. More FDPs were incorporated in women than in men in 9 of 11 studies. On average, 56% of the study populations were women. The number of FDPs at baseline was very different across the studies, ranging from 18 to 65 (Table 1).

The dropout rate within the observation period was low in both groups (approximately 5% in each) and the mean observation period was similar in both groups (zirconia FDPs: 3.3 ± 1 years, PFM FDPs: 2.9 ± 0.3 years). However, the longest observation period (5 years) was recorded for only zirconia FDPs.

Ten studies were carried out at universities or test centers and two with general practitioners.

Characteristics of FDPs

The only study of FDPs on implants was excluded from the comparative analysis since the number was too small (n = 10).[32] Cantilever FDPs were inserted in three studies, which were excluded from further analysis.[22,29,31] Eventually, baseline data were available for 627 zirconia FDPs and 134 PFM FDPs. Due to

Table 1 Study Characteristics

Study	Core material	Veneer material	Type of restoration	No. of subjects at baseline	No. of FDPs at baseline	No. of FDPs included	Observation period (y)
Beuer et al[19]	Cercon	Cercon Ceram Express	ZI, P	19	21	21	3
Crisp et al[20,21]	Lava	Lava Ceram	ZI, L	37	38	38	3
Edelhoff et al[22]	Digizon	Initial	ZI, L	18	22*	21	3
Eschbach et al[23]	In-Ceram ZIRCONIA	Vitadur Alpha	ZI, L	58	65	65	4
Molin and Karlsson[24]	Denzir	Vita D	ZI, L	18	19	19	5
Pospiech and Nothdurft[25]	Lava	Lava Ceram	ZI, L	36	38	38	3
Raigrodski et al[4] and Yu et al[26]	Lava	Lava Ceram	ZI, L	16	20	20	4
Sailer et al[5]	Cercon	Cercon Ceram S	ZI, L	45	57	39	4
Sailer et al[17]	Cercon	Cercon Ceram S	ZI, L	30	38	36	3
	Degudent U	Duceram Plus	PFM, L	29	38	31	3
Sorensen et al[27]	e.max ZirCAD	e.max Ceram	ZI, L	20	20	19	3
Suárez et al[28]	In-Ceram ZIRCONIA	Vitadur Alpha	ZI, L	16	18	18	3
Tinschert et al[29]	DC-Zirkon	Vita D	ZI, L	46	65†	56	3
Christensen et al[6,18]	Cercon	Ceramco PFZ	ZI, L	32	32	31	3
	Captek	Creation	PFM, L	32	32	32	3
	Ceramco 3	Ceramco Soft Wear SF	PFM, L	32	32	32	3
	Everest	Initial	ZI, L	32	32	32	3
	Lava	Lava Ceram	ZI, L	32	32	32	3
	Argen 65	Pulse Interface	PFM, P	32	32	32	3
	Everest	CZR Press	ZI, P	33	33	33	3
	e.max ZirCAD	e.max ZirPress	ZI, P	33	33	33	3
Vult von Steyern et al[30]	DC-Zirkon	Vita D	ZI, L	18	20	20	2
Wolfart et al[31]	Cercon	Cercon Ceram S	ZI, L	51	61‡	24	4

ZI = zirconia; PFM = porcelain-fused-to-metal; L = layered; P = pressed.
*1 cantilever; †2 cantilevers; ‡37 cantilevers.

early dropouts, the numbers were reduced to 595 zirconia FDPs and 127 PFM FDPs (Table 1). The majority of zirconia-based FDPs were three-unit FDPs (n = 543); some had more than three units (n = 52). The PFM FDPs were almost exclusively three-unit FDPs (n = 125); only 2 had more than three units. Almost 74% of the zirconia FDPs replaced molar teeth (n = 438), 121 replaced premolar teeth, and 36 were incorporated in the anterior region. Of the PFM FDPs, 113 replaced molars and 14 replaced premolars. The location in the mouth (maxilla or mandible) was almost equally distributed within the zirconia group. However, five studies did not report on that issue. For the zirconia FDPs, 11 different veneering materials were used on 8 different core materials. For the PFM FDPs, 5 different veneering materials were used in conjunction with 5 different core materials (Table 1).

The veneer thickness of the zirconia FDPs ranged between 0.5 and 2 mm (reported in 10 studies); sandblasting of the core prior to cementation was reported in 6 of 10 studies (185 of 319 FDPs, 58%). The veneer was anatomically supported by the core in 5 of 7 studies (137 of 195 FDPs, 70%). The connector area dimensions of the zirconia core varied between 9 and 16 mm2 for the posterior region and between 6 and 16 mm2 for the anterior region.

Most zirconia and PFM FDPs were cemented with glass ionomer or resin-modified glass-ionomer cement (n = 369 and n = 96, respectively), followed by resin cement (n = 142 and n = 31, respectively), and zinc phosphate (n = 84 and n = 0, respectively).

Fig 1 *(right)* Chipping frequency of zirconia and PFM FDPs. Note that in the studies by Christensen et al,[6,18] no differentiation was made between grades 1 and 2.

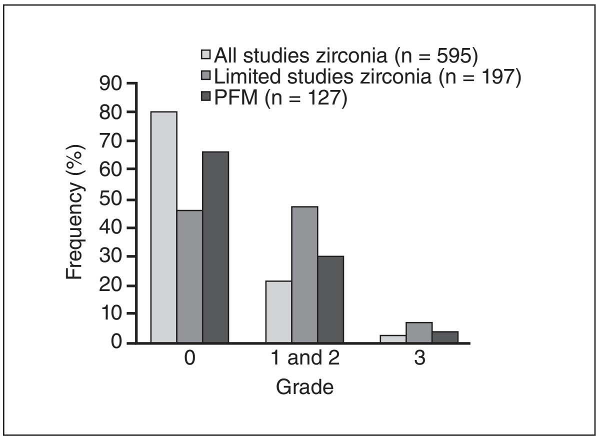
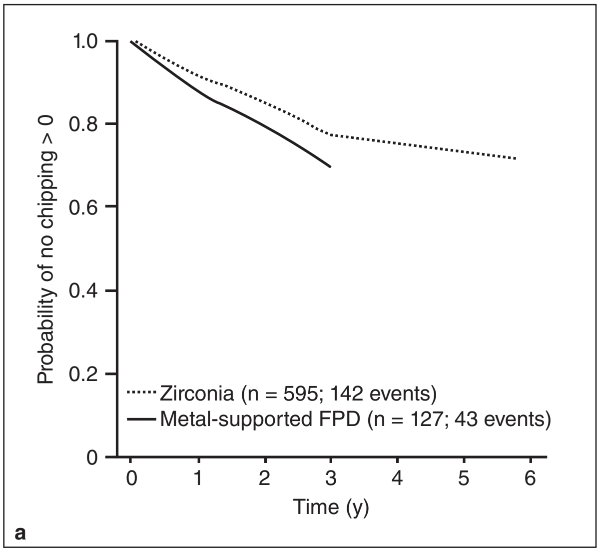
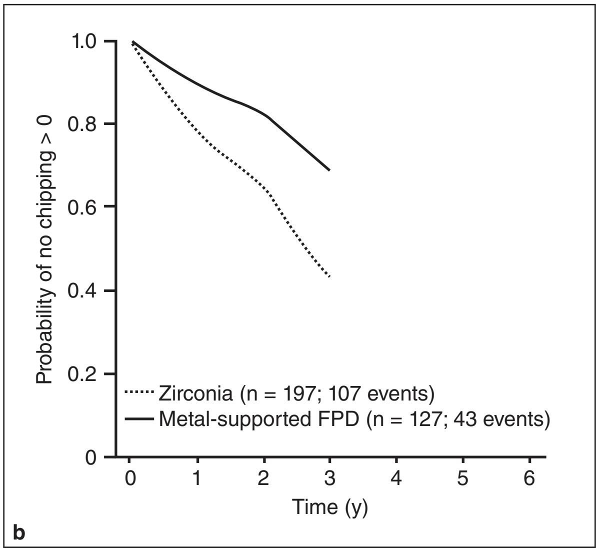


Fig 2 *(below)* Piecewise exponential model of chipping probability **(a)** for all studies and **(b)** studies that directly compared metal and zirconia FDPs (Sailer et al[17] and Christensen et al[6,18]).





Core Fractures

Core fractures occurred in less than 1% of the zirconia FDPs (5 of 595 FDPs); however, none of the metal cores fractured.

Veneer Chipping

One hundred forty-two (24%) veneer chippings were recorded for the zirconia FDPs, and 43 (34%) were recorded for the PFM FDPs. For both PFM and zirconia FDPs, the frequency of grade 1 and 2 veneer chippings was considerably higher than the frequency of grade 3 (Fig 1). When all zirconia and PFM FDPs were included in a comparison based on relative frequencies only, the distribution was similar for all three grades (Fig 1). In a model that used data from all studies and did not allow for the study effect, the frequency of chipping was higher and almost statistically significant (P = .057), with more chipping for the PFM FDPs than zirconia FDPs (Fig 2a). However, when including only those studies that directly compared zirconia and PFM FDPs, the frequency of chipping was significantly higher for zirconia (P < .001, Fig 2b). The reason for these contradictory results was the large variability of the prevalence of chippings across studies (Fig 3), which is an indication of a strong study effect. Four research groups reported especially high chipping rates[4–6,17,18,26]; 85% of all chippings occurred in these studies, which comprised 43% of all zirconia FDPs included in this review. When including a study effect in the model fit to use data from all studies, a significantly higher chipping rate for zirconia was found (P < .001, Figs 4a and 4b). Similar results were found when only those studies that directly compared metal- and zirconia-supported FDPs were included (P < .001, Figs 4c and 4d).

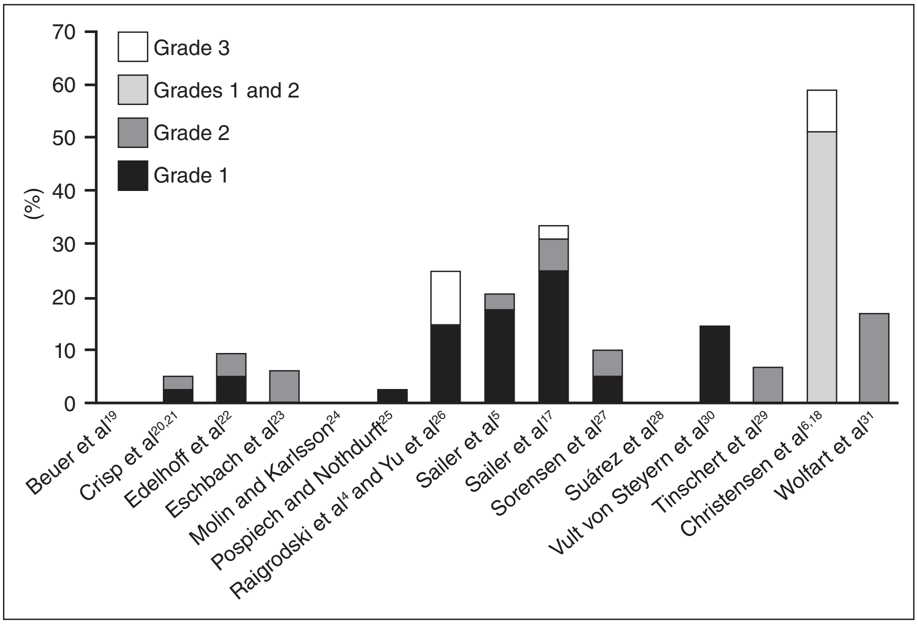
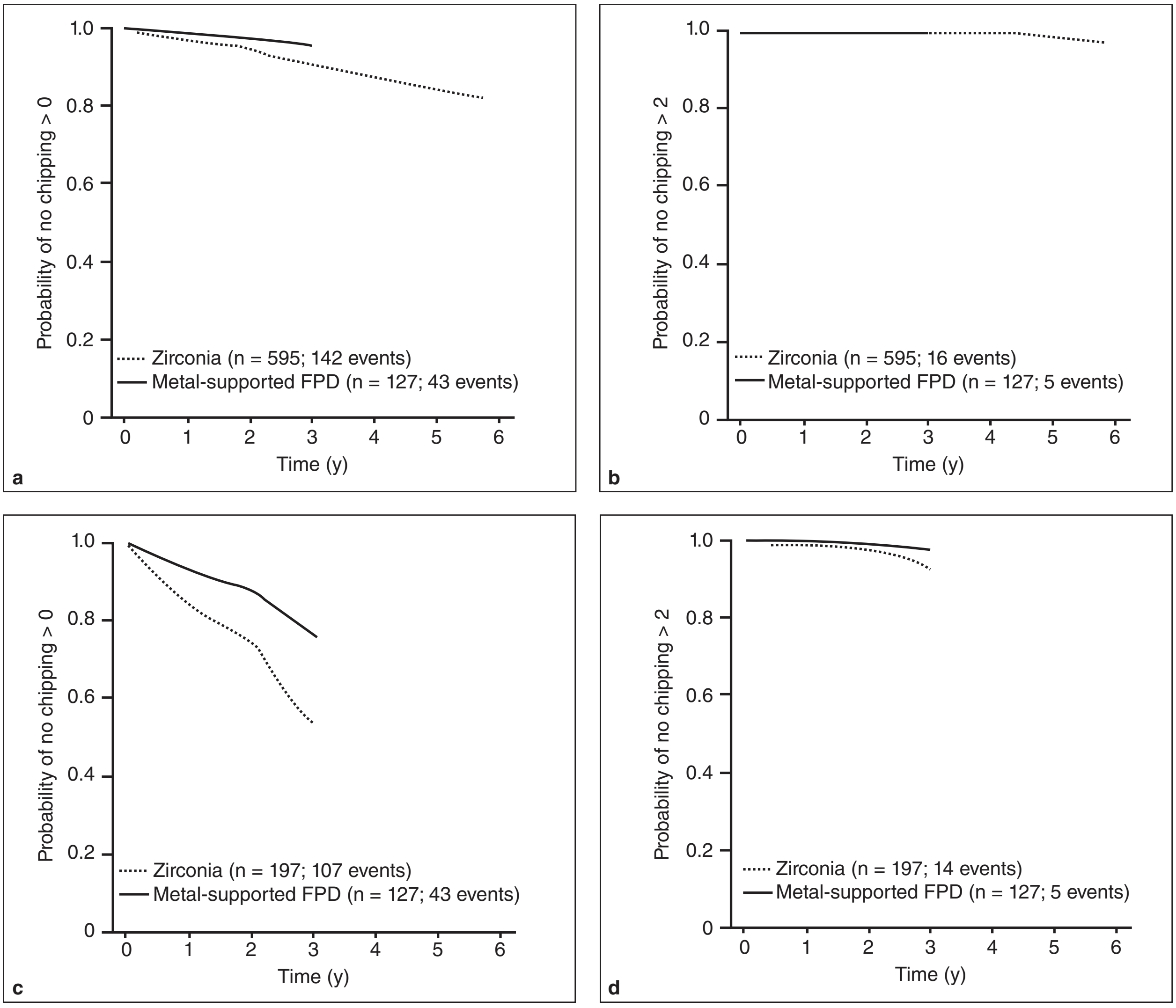


Fig 3 *(left)* Distribution of veneer chipping grade of zirconia FDPs in relation to individual studies. Note that in the studies by Christensen et al,[6,18] no differentiation was made between grades 1 and 2.

Fig 4 *(below)* Piecewise exponential model with study effect **(a)** for all three grades of veneer chipping (chipping > 0) in all studies, **(b)** for grade 3 of veneer chipping (chipping > 2) in all studies, **(c)** for all three grades of veneer chipping (chipping > 0) in the studies by Christensen et al[6,18] and Sailer et al,17 and **(d)** for grade 3 of veneer chipping (chipping > 2) in the studies by Christensen et al[6,18] and Sailer et al.[17]



For zirconia FDPs, veneer chipping was significantly higher for layered veneers than for pressed veneers, but only when all types of chipping were included (grades 1 to 3, P = .046). When only those FDPs with grade 3 chipping were included, a statistically significant difference between layered and pressed FDPs was not detected (P = .116). However, the PFM FDPs also showed a statistically significant difference between layered and pressed veneers for all grades of chipping (P = .044) and for grade 3 chipping alone (P= .043). There were significantly more chippings in the maxilla than in the mandible for zirconia FDPs (P= .016) but not for PFM FDPs. However, the information regarding location in the mouth was available for only 48% of zirconia FDPs and 24% of PFM FDPs. If all types of chipping were included, the survival of PFM FDPs was 97%, compared to 90% for zirconia FDPs after 3 years for a typical study.

The veneer material had a significant influence on the frequency of veneer chipping. The materials Initial (GC), Cercon Ceram (Degudent), and Lava Ceram (3M ESPE) showed statistically significantly more veneer chippings than the VITA materials (Vitadur Alpha and Vita D, Vita Zahnfabrik) (P < .001, Fig 5).

The following parameters did not influence the frequency of veneer chipping significantly: type of replaced tooth (molar, premolar, anterior), number of units, and type of luting cement. Also, technical aspects such as thickness of the veneer, sandblasting prior to cementation, or support of the veneer did not influence the frequency of veneer chipping.

Debonding

For zirconia FDPs, four FDPs debonded among those luted with (resin-modified) glass-ionomer cements (1.1%) and two among those luted with zinc phosphate (2.4%). Debonding was not observed with resin cement. The PFM FDPs were also free of debonding.

Discussion

The review was restricted to FDPs and did not include single crowns since published clinical studies on zirconia-supported crowns are scarce. The data available, however, indicate fewer technical problems for single crowns compared to zirconia-supported FDPs.[33–35]

It was surprising that none of the clinical studies on PFM FDPs included in the systematic reviews fulfilled the inclusion criteria, which are basic criteria for prospective clinical trials. In all studies included in the 3 reviews on PFM FDPs, the main outcome criterion (technical failures) was reported insufficiently. Including data on technical failures whose

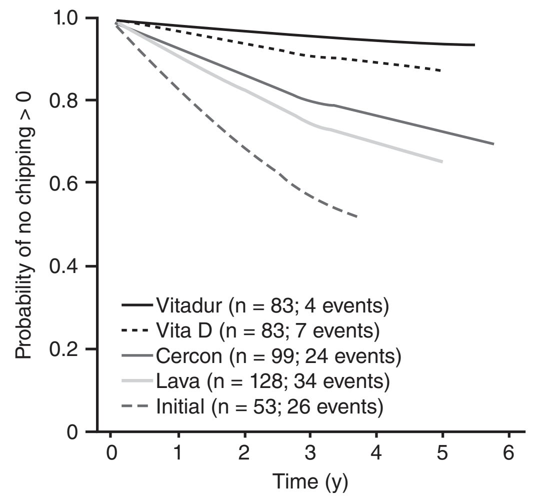


Fig 5 Piecewise exponential model showing the influence of veneer material on chipping (all 3 grades of veneer chipping) in zirconia FDPs.

assessment was incomplete or followed criteria that were different from the ones on zirconia FDPs would not be justified. The authors of the 3 reviews on PFM FDPs noted poor quality of the clinical trials as well. Most of these trials were conducted in the ’70s and ’80s. The quality level of clinical trials in dentistry at that time was low, although good standards had already been established in medicine. Since then, the quality of clinical trials in dentistry has improved substantially. An indication for such improvement is that 12 studies on zirconia were included in the present review. Although some of these studies were lacking important aspects, such as a control group, sample size assessment, randomization of subjects, and details on the FDPs,[36] the main outcome criteria (technical and biologic failures) as well as time to failure and dropouts were all described well. One exception is the studies by Christensen et al,[6,18] for which only abstracts from IADR conferences were available. In these abstracts, however, only a cumulative number of chippings were reported for each zirconia- and metal-supported system. The results are somewhat biased, however, since material defects other than chippings, such as cracks or surface degradation, were included in the chipping grade 1 and 2 categories. However, it was assumed that these phenomena were limited and can be assessed as possible precursors for a chipping event. Besides the study by Sailer et al,[17] the studies by Christensen et al[6,18] were the only randomized clinical trials that used PFM FDPs as a control. For this reason, and since the sample size was high (161 zirconia FDPs and 96 PFM FDPs), it was essential to include these studies, despite the lack of detailed information on chipping dimensions.

Four hypotheses were formulated originally. The main result of this systematic review was that the first hypothesis (zirconia-based FDPs exhibit more chipping than metal-based FDPs) was confirmed. To reach this conclusion, it was crucial to take into account the study effect in the analysis because of the high variation of chipping frequency across the studies. Then, for an observation period of 3 years, veneer chipping of zirconia FDPs was on average 7% higher compared to PFM FDPs for a typical study when the same assessment criteria were applied. For both PFM and zirconia FDPs, the frequency of grade 1 chipping was considerably higher than grades 2 or 3.

On the other hand, the other three hypotheses could not be confirmed. If studies that evaluated more than 50 FDPs of the same veneer material were pooled (n = 5), a significant difference in the frequency was shown for these materials. Therefore, the second hypothesis had to be rejected. Whether the higher frequency of veneer chipping could be attributed to the material or to the technique sensitivity of the processing, or whether there might be other unknown influencing factors, remains unclear. The third hypothesis could also not be substantiated; FDPs with more than three units did not show more chippings than three-unit FDPs. However, this observation is biased since 91% of all zirconia FDPs had three units and only 9% had more than three units. Finally, unsupported cusps did not show more chipping than supported ones, so the fourth hypothesis could not be confirmed either.

Another important conclusion drawn from this review was that the frequency of chipping varied greatly across the studies. Some studies did not report any veneer chipping, and in others, more than 20% or 30% of all FDPs showed veneer chipping. Four research groups reported especially high frequencies of veneer chipping (see Fig 3).[4–6,17,18,26] Of these, one study that examined five different zirconia materials and three different PFM materials reported a very high prevalence of veneer chipping (more than 50%).[6,18] An explanation as to why the results of this study were so different from the results of the other studies is that replicas of all FDPs were produced and examined using scanning electron microscopy. Therefore, small chippings that would otherwise not have been seen during clinical examination were recorded. Another possible reason could be that this study was a practice-based study: 116 general practitioners placed the FDPs. General practitioners might be less careful with the operational procedures (eg, seating of FDPs, occlusal adjustment, polishing) than clinicians at universities. However, another research group[20,21] saw four general practitioners in Great Britain place 38 zirconia FDPs with a relatively low frequency of veneer chipping. It is unclear what caused the higher frequency of veneer chipping in the other studies. The higher frequency was probably not due to the materials used since the same combinations were used in other studies documenting a low frequency of veneer chipping. It can be speculated whether suboptimal parameters during the fabrication of the FDPs or during the incorporation of the FDPs in the oral cavity could account for this. If this is the case, zirconia FDPs have a higher technique sensitivity compared to PFM FDPs, the latter showing significantly less veneer chipping, even if fabrication and evaluation were performed in the same environment and by the same technicians and operators.

The difference in chipping frequencies between the different studies could also be explained by the different clinical grading of chipping. Minor chippings may be recorded by one research institute but not by another. This point may also give some bias to the reportedly low chipping frequency of PFM restorations in former systematic reviews. There is a need to create a chipping index that pays attention to the extent of the chipping (minor, large, or extending to the core), its location (buccal, oral, or interproximal), whether it affects the esthetic appearance or function of the restoration, and whether it is repairable. If the analysis is restricted to only the most severe grade 3 chipping, which leads to the replacement of the FDP, the frequency of PFM FDP chipping is comparable to that reported in the systematic review by Tan et al.[7] This review reported that the estimated 10-year risk of veneer chipping was 3.2% (95% confidence interval: 1.5 to 6.5); in the present study, the mean frequency of grade 3 chipping for the PFM FDPs was 3.9%.

The question of interest for the practitioner is how zirconia-based materials can be improved to reduce the risk of veneer chipping. When zirconia materials were introduced, it was thought that they could be handled similar to PFM materials. Since clinical studies have shown a high frequency of chipping of the veneer material, dental manufacturers began to address this issue. Several factors must be taken into account.

- The coefficient of thermal expansion of the veneer and zirconia material must be adjusted. Generally, the veneer material has a higher coefficient than the core, which puts the veneer under tensile stress and helps it to adapt well to the core. The difference in the coefficient, however, should not be too great. If there is a strong misfit, technical failures occur with high frequency.[37]
- The low thermoconductivity of zirconia leads to unfavorable temperature distributions and the development of internal stresses in the veneer material during firing and cooling of the restoration.[38]

Prolonged cooling until the glass ceramic has reached the critical glass transition point resulted in less residual stress.[39,40]
- If the thickness of the veneer exceeds that of the core by twofold or more, the risk of veneer chipping is increased considerably.[41]
- If the veneer is not supported by the core, which means that the cusps that are built up with veneer material do not have an anatomical counterpart on the core side, the risk of veneer chipping is increased.[42] When the first computer-aided design/computer-assisted manufacturing systems were brought to the market, the software of some systems did not allow the core to be designed anatomically. Since then, this has changed for most systems.
- Veneer materials with higher strength should be developed. These materials must withstand the occlusal and articulation forces better than the current materials.

Although the last two points did not yield a significant correlation with the frequency of veneer chipping in this systematic review, it can be expected that these configuration parameters are important in reducing the risk of chipping. The studies that reported on veneer thickness and anatomical support of the veneer gave a global statement for all FDPs included in them, but did not characterize or measure each and every FDP.[5,17,22,29,31]

Conclusion

Since the veneer chipping frequency was significantly higher in zirconia FDPs compared to PFM FDPs, and since refined processing procedures such as prolonged cooling during the last firing cycle have yielded better results in the laboratory, clinical studies with these new procedures must confirm whether the frequency of veneer chipping in zirconia FDPs can be reduced to the level of PFM.

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Literature Abstract

Biomechanical effect of platform switching in implant dentistry: A three-dimensional finite element analysis

The purpose of this in vitro study was to analyze and compare the implant-bone interface stresses in anisotropic three-dimensional finite element (FE) models of an osseointegrated implant with platform switching and a conventional matching-diameter implant and abutment in the posterior maxilla. Computed tomography images of a human maxilla were obtained of the edentulous maxillary first molar area. An implant was embedded into this cross-sectional area using the 10-mm Osseotite Certain implant as a reference model. One FE model simulated a 4.1-mm diameter, 5-mm-high abutment and the other a 3.4-mm diameter, 5-mm-high abutment to simulate platform switching. Loading was simulated by applying an oblique load (vertical load of 100 N and horizontal load of 20 N) from buccal to palatal in four different locations. The FE model was then used to calculate the von Mises stress distribution. The results showed that maximum von Mises stresses, both compressive and tensile in compact bone, were lower in the platform-switched model as compared with the non–platform switched model but stresses in cancellous bone were higher for the platform-switched model. The authors postulated that high compressive stresses may compromise vascularity, leading to bone necrosis and bone loss. The platform-switched design may decrease the chances of compact bone resorption and loss of integration around the implant.

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