Clin Oral Invest (2012) 16:401–405
DOI 10.1007/s00784-011-0511-5

ORIGINAL ARTICLE

Risk of chipping or facings failure of metal ceramic fixed partial prostheses—a retrospective data record analysis

Michael Behr · Christina Winklhofer · Maria Schreier · Florian Zeman · Carola Kobeck · Isabel Bräuer · Martin Rosentritt

Received: 11 June 2010 / Accepted: 9 January 2011 / Published online: 2 February 2011

Abstract This retrospective study investigated the frequency and time history of chipping or facings failure of three-unit and four-unit tooth-supported metal ceramic (MC) fixed partial prostheses (FPDs). Six hundred fifty-four MC FPDs were inserted according to a standardized treatment protocol at the Department of Prosthodontics of the Regensburg University Medical Center between 1984 and 2009. Frequency and time history of chipping or facings failure as well as possible risk factors were evaluated on the basis of historical clinical data. We estimated the survival times of FPDs by means of the Kaplan–Meier analysis. The 5-year survival rate (time to renewal of a FPD) of all MC FPDs was 94%; the 10-year survival rate was 87%. Twenty-eight (4.3%) MC FPDs showed chipping; the 5-year free-of-event rate of chipping was 95%, the 10-year rate was 94%. Possible risk factors had no statistically significant influence on chipping or facings failure. The annual hazard rate of MC chipping in the first year was 0.03, i.e., 3 out of 100 person-years of exposure showed chipping. The annual hazard rates for the next 6 years dropped to 0.009, 0.003, 0.007, 0.004, 0.005, and 0.007. Thus, about 3–9 out of 1,000 person-years of exposure showed chipping. Patients with MC FPD may expect a long survival rate of their restoration. During the first year, the risk of chipping may be higher than during the following years. Despite the long period of experience with MC FPDs, chipping of the facing will still occur.

Keywords Chipping · Metal ceramic · Precious alloy · Survival · Long-term results · Fixed partial prosthesis

M. Behr (✉) · C. Winklhofer · M. Schreier · F. Zeman · C. Kobeck · I. Bräuer · M. Rosentritt
Department of Prosthodontics,
Regensburg University Medical Center,
93042 Regensburg, Germany
e-mail: Michael.behr@klinik.uni-regensburg.de

Introduction

Metal ceramic (MC) fixed partial prostheses (FPDs) have been successfully used for more than four decades [1]. These prostheses are considered a reliable and long-lasting device in oral service. For many dentists, MC FPDs represent the gold standard for restoring small gaps in the dental arch [2, 3]. By now, all-ceramic restorations made of zirconia have replaced metal-based FPDs, probably because of their higher biocompatibility and preferable esthetic appearance, the new CAD/CAM manufacturing procedures for all-ceramics, and the increasing costs for precious alloys [1, 4, 5]. However, chipping or facings failure of zirconia-based FPDs have been reported frequently [4, 5]. Many dentists believe the risk of chipping of facings failure to be higher for zirconia than for MC FPDs [5]. But, is this assumption true? Although MC FPDs have been used for decades, few clinical studies are available [6–9], which show that the risk of chipping or facings failure of MC FPDs is indeed neglectfully low.

This retrospective study aimed at generating data about the risk of chipping or facings failure of MC FPDs that were inserted at the Department of Prosthetic Dentistry between 1984 and 2009. Based on the records of the clinical history data of MC FPDs made of precious alloys, we analyzed the potential risk factors for chipping and calculated the survival rate and the hazard rate (λ) of the risk of chipping per year.

Material and methods

A search tool of dental software (Report Smith of Highdent Plus, Systema, Koblenz, Germany) generated the number of tooth-supported MC FPDs made of precious alloy (implant-supported MC FPDs were excluded); 886 MC FPDs were inserted at the Department of Prosthodontics of the Regensburg University Medical Center between 1984 and 2009. We excluded all FPDs made of other dental materials, such as non-precious alloy, glass fiber-reinforced composite, and all-ceramic (n=41). Furthermore, cases with incomplete records were excluded (n=15). In 254 out of the 886 remaining MC FPDs made of precious alloy, patients had received more than 1 FPD. Only the first FPD documented in the clinical data was chosen for this investigation. All other FPDs of such patients were excluded. Therefore, we finally analyzed 654 FPDs. Table 1 shows further details about this sample. The FPDs had been made according to a standardized treatment protocol by full-time staff of the department [10]. After FPD insertion, patients were instructed to undergo at least one follow-up examination per year.

We retrospectively evaluated the frequency and time point of chipping or facing failure as well as possible risk factors on the basis of historical clinical data. Risk factors were bruxism, type of antagonists (fixed vs. removable dentures), FPD location (mandible, maxilla, anterior, or posterior area), core build-up material, or luting agent.

Table 1 Description of the sample of 654 MC FPDs

Cases (n=654)	Three-unit FPDs (n=484) Four-unit FPDs (n=170)
Women	n=359 (54.9%)
Men	n=295 (45.1%)
Posterior area	n=502
Anterior area	n=33
Midline crossing	n=28
Premolar region	n=91
Mandible	n=326
Maxilla	n=328
Antagonist	
Fixed denture or natural teeth	n=597
Removable denture	n=45
Full denture	n=12
Core build-up	
None	n=128 (18.8%)
Zinc-oxide–phosphate	n=10 (1.5%)
Glass ionomer	n=174 (26.6%)
Metal-reinforced Glass ionomer cement	n=36 (5.5%)
Resin-modified GIC	n=2 (0.3%)
Compomer	n=26 (4.0%)
Composite	n=283 (43.3%)
Luting agent	
Zinc-oxide–phosphate	n=309 (47.2%)
Zinc oxide–eugenol	n=257 (39.3%)
Glass ionomer	n=60 (9.2%)
Adhesive	n=28 (4.3%)

GIC Glass ionomer cement

Chipping was defined as any loss of substance of the ceramic facing, which could not be attributed to any forms of wear. In case of intolerable or unrepairable substance loss, a new FPD had to be made. Such cases—decided upon by a dentist—were rated as a "failure." Chipping never occurred regularly with the recall intervals. It may happen randomly at any time during the observation period. Therefore, the time point when chipping was noticed by a dentist could be either the yearly recall examination or when a patient recognized it, and asked for an appointment because of a faulty facing.

Statistics

We calculated the survival time of the MC FPDs by means of the Kaplan–Meier (KM) analysis. Statistical differences between the subgroup levels were determined with the Logrank test (α=0.05) [11, 12]. One case was rated "termination due to failure" (event) when a FPD lost its function and a new denture had to be made. FPDs that were not replaced or did not fail at their final examination were classified as censored. A Cox regression analysis determined the impact of covariates, such as the type of antagonist, three-unit or four-unit FPD, bruxism, location (upper or lower jaw), anterior or posterior area, core build-up material, and luting agent. Subcategories including less than 10 cases were excluded.

Clinicians need to know at what time point chipping or facings failure may be expected. We based this calculation on clinical cases with only one event; therefore, the time considered was not based on the entire observation time but on the event-related time. The hazard rate (λ) was estimated within specific time intervals by dividing the total survival period into time segments, counting the number of events occurring in the segment, and dividing the number of events by the number of patients at risk during that segment (see Table 2).

Results

The median follow-up time of 3 years was calculated with the inverse KM method. The 5-year survival rate (time to renewal of a FPD) of all MC FPDs was 94%; the 10-year survival rate was 87%. Twenty-eight (4.3%) MC FPDs showed chipping; the 5-year free-of-event rate for chipping was 95%, the 10-year rate was 94%. Possible risk factors, such as bruxism, type of antagonists, maxilla, mandible, or posterior or anterior area, had no statistically significant influence on chipping or facings failure. The annual hazard rate of MC chipping in the first year was 0.03, i.e., 3 out of

Table 2 Calculation of the hazard rate (λ)

Example first year
$f_1 = (n_{\text{patients}}\text{with event} \times n_{\text{months}}) + (n_{\text{patients}} \times n_{\text{months}}) = n_{\text{months of exposure}}$
$F_1 = (n_{\text{patients}}\text{without event censored} \times n_{\text{months}}) + (n_{\text{patients}} \times n_{\text{months}})$
Total exposure during the first year for all patients $= f_1 + F_1$
Hazard rate $\lambda_1 = \text{event}_1/(f_1 + F_1)$(number of events per $\times$ person $-$ years during first year)
$\lambda_2 = \text{event}_2/(f_2 + F_2)$

100 person-years of exposure showed chipping. The annual hazard rates for the next 6 years dropped to 0.009, 0.003, 0.007, 0.004, 0.005, and 0.007. Thus, about 3–9 out of 1,000 person-years of exposure showed chipping.

Discussion

Method

No comprehensive clinical data exist about the risk of chipping or facings failure of MC FPDs that conform to today's standards of evidence-based clinical outcome trials [9]. Therefore, retrospective studies may help to get an insight into the chipping behavior of MC FPDs. Such studies may offer a scope for designing longitudinal studies in the future, particularly studies of a comparative nature. This retrospective study has a limited perspective because it is based on already existing clinical history data. However, the use of a standard treatment protocol for denture construction provides a high level of reproducibility. On the other hand, different opinions and decisions of the staff members or patients may have influenced the results. For example, the decision to rate a FPD as "chipped" may lead to bias, because chipping may happen any time. Some patients could assess minor degrees of chipping as not important or did not recognize the FPD as chipped. Other patients may have wished the removal of the prosthesis for esthetic or personal reasons. Therefore, we defined "chipping" as any loss of substance of the ceramic facing, which could not be attributed to any form of wear, and this decision was made by a member of the staff.

The perspective of this study is also limited because the number of clinical cases under observation decreased with time. The mean follow-up time was 3 years. After more than 10 years, the cases under risk were considerably reduced (see Fig. 1 or 2). As a consequence, events occurring 10 years later, for example, could have an undue impact on the hazard rate. Figure 3 shows that the risk of chipping seemed to dramatically increase in the 13th year. The reason for this increase is that two events (chipping) randomly occurred during that year, whereas no chippings were noted 6 years before and after these two events. Only

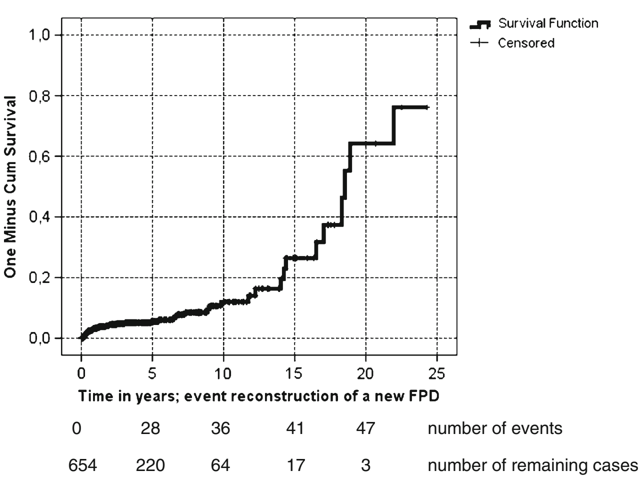

Fig. 1 One minus cumulative survival of three-unit and four-unit MC FPDs. The number of cases under observation with increasing time and the corresponding number of the event "reconstruction of a new FPD" are depicted. Censored cases are marked with +

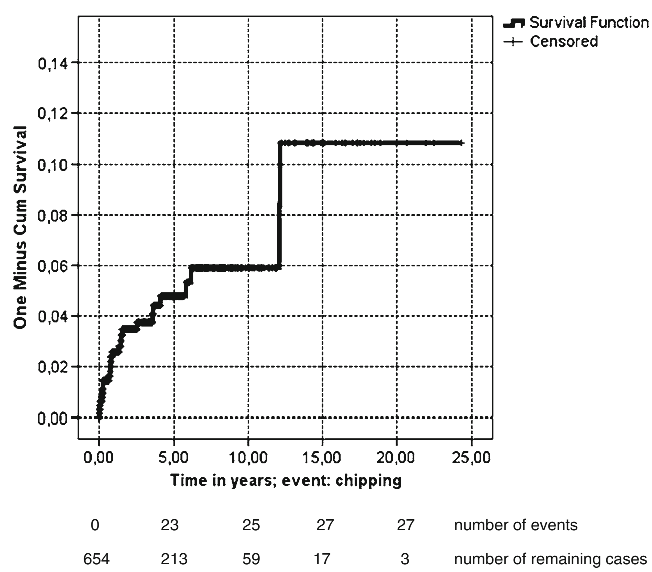

Fig. 2 One minus cumulative survival of three-unit and four-unit MC FPDs. The number of cases under observation with increasing time and the corresponding number of the event "chipping" are depicted. Censored cases are marked with +

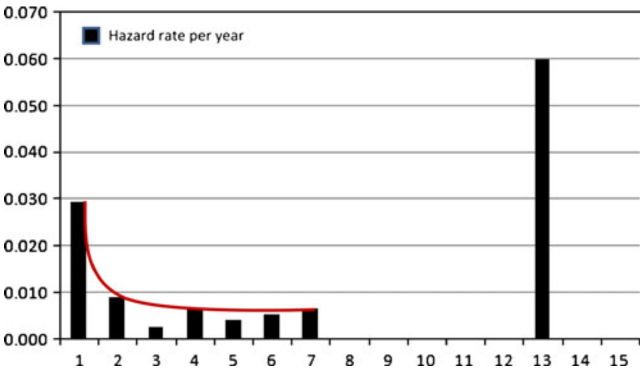

Fig. 3 Hazard rate l, risk in summarized person-years per year. Example, the annual hazard rate of chipping of MC in the first year was 0.03, i.e., 3 out of 100 person-years of exposure had chipping. Description of the statistics, see text

30 remaining cases were under risk during this time segment; thus, the calculated hazard rate of this particular year projects a risk that does not exist at all.

Data interpretation

Chipping or facings failure of MC FPDs is a rare event. In our study, such an event only occurred in 4.3% (n=28; 654) of all clinical cases. The 10-year free-of-event rate of chipping was 94%. The results were comparable with those reported by Reichen-Graden and Lang (94.5%) [6], Napankangas (94.1%) [7], or Walton (95%) [8]. A systematic review (1966–2004) of Tan [9] analyzing 19 studies calculated the 10-year risk of “material fracture” to be 3.2%. However, most studies reported complications such as chipping as simple proportions associated with the mean patient follow-up time instead of the mean complication follow-up. Furthermore, these studies did not differentiate between framework failures and ceramic failures and different materials such as precious or non-precious alloys were mixed in the data. Some studies showed that the risk of facings failure of MC FPDs made with non-precious alloy could be higher than that of MC FPDs made with precious alloys. Walter et al. [13] reported that titanium-based restorations showed considerably more chipping or facings failure (45.5%; p=0.0049) over 6 years than high-gold alloy restorations (0.04%). In a retrospective study lasting 3–7 years, Eliasson and colleagues found 17.6% of ceramic fractures in cobalt–chromium alloy-based FPDs [14]. All in all, these data indicate that the risk of chipping or facings failure is lowest when porcelain is fused to high precious alloys.

The Cox regression model could not show any potential risk factors for chipping, such as bruxism, location of the restoration in the jaw, or type of antagonists (Table 3). This finding was rather unexpected because a study by Kinsel et al. [15], for example, showed a seven-times higher risk of porcelain fractures for patients with bruxism. The same high odds ratio was calculated for patients when comparing implant-supported restorations with natural teeth. Kinsel supposed that the absence of a neurosenory mechanism, which adequately compensates for the periodontal ligament's proprioception and compressibility, leads to the higher incidence of porcelain fractures.

Figure 3 shows that chipping or facings failure most frequently occurred during the first year after insertion. Other investigations confirm this observation. Therefore, this ceramic failure is not caused by any fatigue phenomena due to long-lasting overload produces within increasing observation time. In our opinion, such early failures reflect errors made during the manufacturing process. These errors include [16–18]:

- Non-anatomical framework design
- Wrong firing temperature
- Too fast cooling temperatures resulting in tensile stress in the ceramic
- No cooling during occlusal adjustment
- No polishing after adjustment

Table 3 Cox regression: potential risk factors which may have an impact on the event “chipping”

Variables in the equation	B	SE	Wald	*df*	Sig	Exp (B)	95.0% CI for exp (B) Lower	Upper
Type of antagonist	0.062	0.527	0.014	1	0.906	1.064	0.379	2.989
Mandible/maxilla	0.045	0.411	0.012	1	0.912	1.046	0.468	2.340
Anterior/posterior	−0.264	0.341	0.601	1	0.438	0.768	0.394	1.498
Three-unit/four-unit FPD	−0.302	0.469	0.414	1	0.520	0.740	0.295	1.853
Type of luting agent	0.092	0.097	0.904	1	0.342	1.097	0.907	1.326
Type of core build-up	0.041	0.102	0.158	1	0.691	1.041	0.852	1.272
Parafunctions	0.28	0.466	0.004	1	0.952	1.028	0.413	2.563

FPD Fixed partial denture; *Sig* significance; *Exp B* Exponent B; *CI* Confidence interval; *df* degree of freedom; *B* B-value; *SE* Standard error of mean

This study does not provide any data which could confirm that the ceramic failures observed were linked to the abovementioned manufacturing errors. However, all these factors have been intensively discussed for zirconia or titanium. In our opinion, the production of MC FPDs made of precious alloys may be easier than the production of non-precious alloys or zirconia.

Conclusion

Patients with MC FPD may expect a long survival rate of their restoration. During the first year, the risk of chipping may be higher than during the following years. However, MC FPDs made of a precious alloy have a low risk of chipping.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Christensen GJ (2005) Longevity of posterior tooth dental restorations. JADA 136:201–203
2. Rosenstiel SF, Land MF, Rashid RG (2004) Dentists molar restoration choices and longevity: a web-based survey. J Prosthet Dent 91:363–367
3. DeBacker H, Van Maele G, DeMoor N, Van den Berghe L, DeBoever J (2006) A 20-year retrospective survival study of fixed partial dentures. Int J Prosthodont 19:143–153
4. Raigrodski AJ (2005) All-ceramic full-coverage restorations: concepts and guidelines for material selection. Pract Proced Aesthet Dent 17:249–256
5. Donovan TE (2008) Factors essential for successful all-ceramic restorations. Factors essential for successful all-ceramic restorations. JADA 139:14S–18S
6. Reichen-Graden S, Lang NP (1989) Periodontal and pulpal conditions of abutment teeth. Status after four to eight years following the incoporation of fixed reconstructions. Schweiz Monatschr Zahnmed 99:1381–1385
7. Napankangas R, Salonen-Kemppi MA, Raustia AM (2002) Longevity of fixed metal ceramic bridge prostheses: a clinical follow-up study. J Oral Rehabil 29:140–145
8. Walton TR (2003) An up to 15-year longitudinal study of 515 metal-ceramic FPDs: part 2. Modes of failure and influence various clinical characteristics. Int J Prosthodont 16:177–182
9. Tan K, Pjetursson BJ, Lang NP, Chan ES (2004) A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. III. Conventional FPDs. Clin Oral Impl Res 15:654–666
10. Shillingburg HT, Hobo S, Whitsett LD (1981) Fundamental of fixed prosthodontics, 2nd edn. Quintessence Publishing, Chicago
11. Kaplan E, Meier P (1958) Nonparametric estimation from incomplete observation. J Am Stat Assoc 53:457–481
12. Pocock SJ, Clayton TC, Altman DG (2002) Survival plots of time-to-event outcomes in clinical trials: good practice and pitfalls. Lancet 359:1686–1689
13. Walter M, Reppl PD, Böning K, Freesmeyer WB (1999) Six-year follow-up of titanium and high-gold porcelain-fused-to-metal fixed partial dentures. J Oral Rehabil 26:91–96
14. Eliasson A, Arnelund CF, Johansson A (2007) A clinical evaluation of cobalt-chromium metal ceramic fixed partial dentures and crowns: a three-to seven-year retrospective study. J Prosthet Dent 98:6–16
15. Kinsel RP, Dongming L (2009) Retrospective analysis of porcelain failures of metal ceramic crowns and fixed partial dentures supported by 729 implants in 152 patients: patient-specific and implant-specific predictors of ceramic failure. J Prosthet Dent 101:388–394
16. Rosentritt M, Steiger D, Behr M, Handel G, Kolbeck C (2009) Influence of substructure design and spacer settings on the in vitro performance of molar zirconia crowns. J Dent 37:978–983
17. Swain MV (2009) Unstable cracking (chipping) of veneering porcelain on all-ceramic dental crowns and fixed partial dentures. Acta Biomater 5:1668–1677
18. Quinn JB, Sundar V, Parry EE, Quinn GD (2010) Comparison of edge chipping resistance of PFM and veneered zirconia specimens. Dent Mater 26:13–20