Treatment Outcomes of Cantilever Fixed Partial Dentures on Vital Abutment Teeth: A Retrospective Analysis

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Purpose: This retrospective clinical study evaluated the long-term outcomes of cantilever fixed partial dentures (CFPDs) and the factors influencing their survival probability. **Materials and Methods**: The study is based on a convenience sample of 57 patients who received 71 CFPDs on a total of 176 vital abutment teeth. The mean survival time of the CFPDs was calculated using a Kaplan-Meier estimate. The following variables were analyzed as covariates of the survival function (log-rank test, $P < .05$): sex, denture location, number and distribution (Kennedy Class) of the abutment teeth, dentition in the opposing arch (removable dentures, fixed partial dentures, or natural dentition), position of the cantilever unit (mesial or distal), and participation in follow-up visits. **Results:** The mean observation period was 3.2 ± 2.8 years (maximum 10.7 years). During the observation period, 22.5% (n = 16) of the CFPDs ceased functioning. The calculated outcome probability was 93.0% after 5 years and 84.5% after 8 years. The number of abutment teeth was the only parameter that significantly ($P < .05$) impacted this probability. **Conclusion:** The survival rate of CFPDs on vital abutment teeth is comparable to that of conventional fixed partial dentures. Thus, CFPDs on vital abutments are an acceptable alternative to removable dentures. *Int J Prosthodont 2015;28:577–582. doi: 10.11607/ijp.4114*

In contrast to removable dentures, fixed partial dentures (FPDs) generally offer a higher degree of patient satisfaction because they better resemble natural teeth in terms of function and comfort.[1,2] Depending on the distribution of the remaining dentition, a fixed replacement for missing teeth without the placement of implants may require the use of cantilever fixed partial dentures (CFPDs). Often, a unilaterally or bilaterally shortened dental arch is restored with a CFPD to avoid a removable denture.[3,4] CFPDs are characterized by one or more distally or mesially attached levitated pontics.[4–6]

Extra-axial loading of the abutment teeth is the decisive risk factor in CFPD treatment because the application of a load on the cantilever induces lateral and extrusive forces on the abutment teeth and periodontal tissues,[1,7–9] which can result in a loss of retention[1,3,4,6–8,10–16] or cause the abutment teeth to fracture.[3] However, in addition to sufficient retention,[1,3,4,6–8,10–14] the vitality of the abutment teeth[3–5,9–12,14,17] is crucial for the success of CFPDs. Given that nonvital, endodontically treated teeth are prone to fracture, they increase the survival risk for CFPDs, as reported by Decock et al[5] in a longitudinal study. This finding has also been supported by De Backer et al,[11] Hämmerle et al,[12] Randow et al,[14] and Landoldt and Lang,[3] who found more fractures in nonvital abutment teeth. In clinical experiments, Randow and Glantz showed that cantilever loading may contribute to higher failure rates associated with devitalized teeth because the patient's pain tolerance was significantly higher for nonvital abutments compared to vital abutments.[18] This finding is also reflected in a systematic review by Pjetursson et al, who recommended only choosing CFPDs in cases where the abutments consist of vital teeth.[4] The combination of a cantilever extension with a root-filled terminal abutment appears to be predisposed to failure.[17]

Based on these findings (particularly those of Decock et al[5]) and a preliminary analysis of the survival of posts and cores in fixed restorations[18] in our department, only vital teeth were selected as abutments for CFPDs. Thus, the aim of this retrospective clinical study was to evaluate the long-term clinical outcomes of CFPDs that were exclusively retained on vital abutment teeth.

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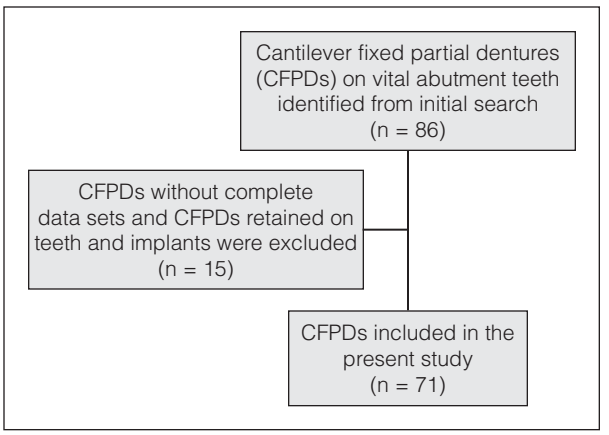

Fig 1 Flow chart of the CFPD selection process.

Table 1 Number of Abutment Teeth for CFPDs (n = 71) Included in the Study

	No. of abutment teeth				
	2	3	4	5	6
No. of CFPDs (n = 71)	54	9	3	1	4

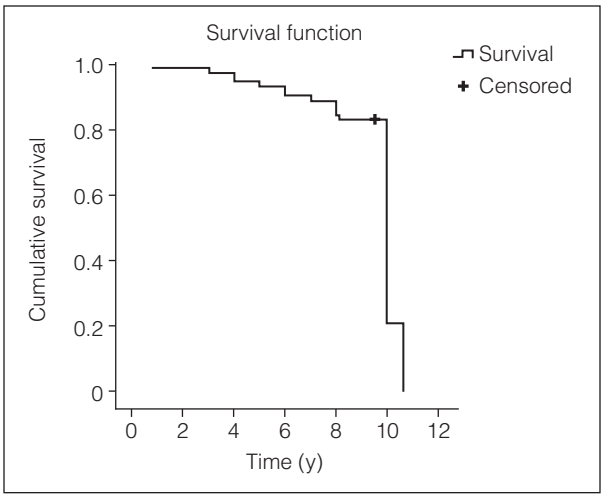

Fig 2 Outcome probability of all CFPDs (target event: renewal), n = 71, Kaplan-Meier.

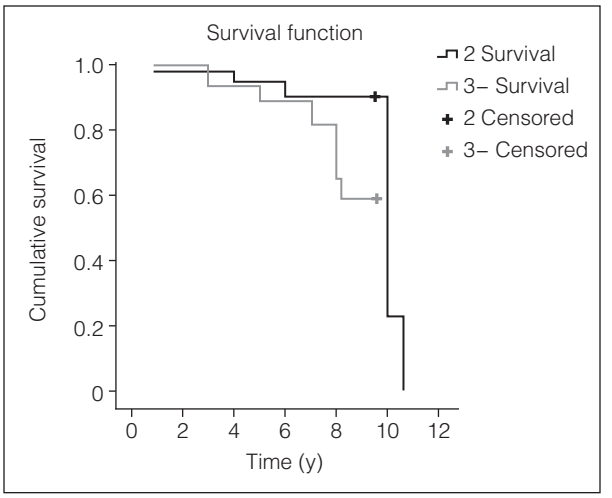

Fig 3 Outcome probability of CFPDs dependent on the number of abutment teeth (target event: renewal), n = 71, Kaplan-Meier.

Materials and Methods

This study is based on a convenience sample of 57 patients (40 women, 17 men; mean age 52.0 ± 13.5 years) who had received 71 CFPDs (Fig 1) on a total of 176 vital abutment teeth (Table 1) within the last 15 years in the Department of Prosthodontics, Justus-Liebig-University, Giessen, Germany. Only CFPDs in patients with periodontally healthy abutment teeth with a minimum of two-thirds of bone support around the root were included in the analysis. Patients with incomplete data sets (missing data after delivering the CFPD) and CFPDs retained on a combination of teeth and implants were excluded.

A total of 39 CFPDs were placed in the maxilla, and 32 were placed in the mandible (variable: denture location). Of these arches, 32 were classified as Kennedy Class I, 27 as Kennedy Class II, and 12 as Kennedy Class III (variable: distribution of remaining natural teeth). Of the patients, 46 had fixed partial dentures, 16 had removable dentures, and 9 had no dental prosthesis or natural dentition opposing the restoration area (variable: dentition in the opposing jaw). Each of the CFPDs had only one cantilever unit (mesial n = 16; distal n = 55; variable: position of the cantilever unit) with premolar proportions. The variable number of abutment teeth is shown in Table 1.

The CFPDs were delivered as part of clinical courses taught in the department under the strict supervision of experienced full-time teachers following a standardized protocol. All CFPDs were fabricated in the same dental laboratory. Prior to treatment, all patients underwent an oral hygiene program. After the CFPDs were cemented, all patients were asked to participate in a continuous annual follow-up program.

The statistical analysis was performed using a Kaplan-Meier estimate, with a 95% confidence interval (CI), for survival analysis.[19,20] The endpoint value selected for a favorable outcome probability was renewal of CFPDs (Figs 2 and 3).

The variables of sex, denture location, number and distribution (Kennedy Class) of abutment teeth, dentition in the opposing jaw (removable dentures, fixed partial dentures [FPDs], or natural dentition), position of the cantilever unit (mesial or distal), and participation in follow-up visits were analyzed as covariates of the survival function (log-rank test, $P < .05$).

This study was approved by the Ethics Committee at the Justus-Liebig-University, Giessen, Germany (reg no. 164/11).

Results

The mean observation time was 3.2 ± 2.8 years (maximum 10.7 years). The number of CFPDs remaining at risk after a specific observation period is shown in Table 2. During the observation period, 22.5% (n = 16) of the CFPDs ceased functioning. A total of 5.1% (n = 9) of the abutment teeth were extracted in seven patients. The reasons for all extractions was periodontal disease.

The expected survival time of the CFPDs was calculated to be 9.4 ± 0.3 (mean ± standard deviation) years (95% CI: 8.9 to 9.9 years); the outcome probability was 93.0% after 5 years and 84.5% after 8 years (Fig 2). The reasons for renewal were caries at the crown margin (n = 8; 6 mandibular, 2 maxillary), framework fractures (n = 1; mandibular), and extraction of abutment teeth (n = 7; 5 mandibular, 2 maxillary).

A significant difference ($P < .05$) was observed in the mean survival time of the CFPDs with two abutment teeth (n = 54), which was 9.6 ± 0.3 (95% CI: 9.0–10.2 years), in contrast to the CFPDs with three or more abutment teeth (n = 17), which was 8.4 ± 0.4 years (95% CI: 7.5–9.2 years) (Fig 3).

Given that no patient regularly attended the follow-up appointments, this variable was not statistically evaluated.

None of the other parameters showed any significant impact ($P > .05$) on the final clinical outcome.

During the observation period, one (1.4%) CFPD had to be reattached to the abutment teeth, and in two patients (2.8%) a direct repair of the veneering material inside the patient's mouth was performed with a special repair set.

Discussion

Currently, because implants are often used to complete a shortened dental arch, CFPDs are mainly used for patients who are unwilling to undergo implant treatment. Thus, the resulting cohort in our observational study included patients with reservations against extensive dental treatment and those who have low compliance, which was reflected by the complete nonresponse to the maintenance program offered. Together, this patient profile explains the low number of patients in our study and the primary reasons for CFPD failures (periodontal disease and caries). If the patients had attended our continuous maintenance program, it is likely that the plaque-induced complications would have been significantly reduced, resulting in a better survival rate.

Table 2 Number of CFPDs at Risk by Year

	Year				
	1	2	3	4	≥ 5
No. of CFPDs (n = 71)	71	59	37	30	23

A search for papers published over the past 30 years identified 29 studies[1,3–17,21–33] analyzing CFPD survival rates (Table 3). In addition, after 5 years, survival rates between 79%[10] and 98%[24] have been reported, with an average failure rate of about 2% per year (Fig 4). This study reported a 93.0% CFPD survival rate after 5 years; this result is in the upper third when compared to the results reported in the literature (Fig 4). However, in most available studies,[1,3,4,6,7,12,13,15,17,21,22,27–33] the survival rate was calculated using input-output statistics that regularly result in an overestimation of the outcome.[19] Additionally, the CFPDs in this study were solely retained on vital abutment teeth. This fact must be considered when comparing our results to the available data. The calculated 5-year CFPD survival rates in this study are within the range of conventional FPDs, with an average 5-year survival probability of 94%, as reported in three meta-analyses,[29,34,35] which is decisively higher than the survival rate reported for CFPDs on endodontically treated abutments, with an estimated 5-year survival rate of 75%.[9] Although our study was not designed to analyze the risk imposed by the inclusion of nonvital abutment teeth, our findings, similar to Randow and Glantz,[18] support the hypothesis that the use of a cantilever and extra-axial loading is not a risk in itself; instead, it is dependent on other risk factors, such as endodontically treated teeth. In contrast to the findings of Leempoel et al,[26] who reported higher survival rates with a greater number of abutment teeth, this study found higher survival rates in CFPDs with only two abutments than in those with three or more abutments. However, our findings agree with data reported for long-span fixed partial dentures.[36,37] It is hypothesized that every abutment tooth has a certain risk of complications, resulting in an overall negative effect on the treatment as a whole.

Denture location, Kennedy Class, and the position of the cantilever unit had no significant influence on the outcome probability in this study, similar to the findings of the few studies that have also analyzed these variables.[5,9,24]

Table 3 Survival Rates of CFPDs in the Literature

Author	Year	Number	Statistical method	Observation period (y)	Survival rate
Izikowitz[25] (Sweden)	1985	69 patients 87 CFPDs	Kaplan-Meier	5 10 15 20	98% FPDs 82% FPDs 69% FPDs 49% FPDs
Karlsson[17] (Sweden)	1986	164 patients 238 CFPDs 944 abutment teeth	Input-output	10	93.3% FPDs
Randow et al[14] (Sweden)	1986	93 FPDs with one cantilever (Group 1) 83 FPDs with two cantilevers (Group 2)	Life table	7	Group 1: 16.1% technical complications, 28.0% caries, 8.6% endodontic complications; 11.8% periodontal complications. Group 2: 33.7% technical complications, 31.3% caries, 22.9% endodontic complications, 7.2% periodonal complications
Hochman et al[6] (Israel)	1987	27 patients 29 CFPDs	Input-output	10	100% FPDs
Landolt and Lang[3] (Switzerland)	1988	61 patients 80 CFPDs 154 abutment teeth (96 vital abutments, 58 nonvital abutments)	Input-output	Ø 4, 6	2% failure for vital abutments 40% failure for nonvital abutments
Karlsson[13] (Sweden)	1989	36 CFPDs 105 abutment teeth	Input-output	14	66.7% FPDs
Reichen-Graden and Lang[15] (Switzerland)	1989	21 CFPDs	Input-output	Ø 6, 4	7.4% technical complications
Budtz-Jørgensen and Isidor[1] (Denmark)	1990	27 patients 41 CFPDs 79 abutment teeth	Input-output	5	80.5% FPDs 98.7% abutments
Laurell et al[7] (Sweden)	1991	34 patients 36 CFPDs	Input-output	Ø 8, 4	94.4% FPDs
Öwall et al[28] (Denmark)	1991	11 patients 11 CFPDs	Input-output	20	45.5% FPDs
Palmqvist and Swartz[29] (Sweden)	1993	34 CFPDs	Input-output	18–23	74.5% FPDs
Leempoel et al[26] (Netherlands)	1995	235 CFPDs	Kaplan-Meier	1 5 10 12	99.6% FPDs 96.5% FPDs 89.8% FPDs 85.8% FPDs
Yi et al[32,33] (Sweden)	1995 1996	43 FPDs, of which 31 are CFPDs	Input-output	Ø 14–15	70% FPDs
Carlson and Yontchev[22] (Sweden)	1996	12 patients 12 CFPDs	Input-output	9.5	50% FPDs
Decock[5] (Belgium)	1996	100 patients 137 CFPDs	Kaplan-Meier	18	70% FPDs
Sundh and Ödman[31] (Sweden)	1997	31 CFPDs 98 abutment teeth	Input-output	18	67.7% FPDs 63.3% abutments
Lindquist and Karlsson[27] (Sweden)	1998	140 FPDs, of which 36 are CFPDs	Life table	20	65.4% FPDs
Hämmerle et al[12] (Switzerland)	2000	92 patients 115 CFPDs 239 abutment teeth	Input-output	Ø 10	84% FPDs
Yi et al[33] (Korea)	2001	50 FPDs, of which 33 are CFPDs	Input-output	3	100% FPDs
Holm et al[24] (Sweden)	2003	235 patients 289 FPDs, of which 42 are CFPDs	Life table	10 20 30	72% FPDs 64% FPDs 53% FPDs
Pjetursson et al[4] (Switzerland)	2004	Meta-analysis (13 studies, 700 patients, 816 CFPDs)	Input-output	10	81.8% FPDs
Rinke et al[8] (Germany)	2006	21 patients, 26 oxide-ceramic CFPDs (Cercon)	Input-output	Ø 1, 7	100% FPDs
De Backer et al[11] (Belgium)	2007	137 CFPDs	Kaplan-Meier	16 18	73.5% FPDs with vital abutments 52.3% FPDs with nonvital abutments

Table 3 *continued* Survival Rates of CFPDs in the Literature

Author	Year	Number	Statistical method	Observation period (y)	Survival rate
Eliasson et al[23] (Norway)	2007	42 patients 51 FPDs, of which 32 are CFPDs	Input-output	Ø 4, 3	88% FPDs
Pjetursson et al[30] (Switzerland)	2007	Meta-analysis (13 studies, 816 CFPDs)	Input-output	5 10	91.4% FPDs 80.3% FPDs
Wolfart et al[16] (Germany)	2009	34 oxide-ceramic CFPDs (Cercon)	Kaplan-Meier	4	92% FPDs
Brägger et al[10] (Switzerland)	2011	39 CFPDs	Kaplan-Meier	5 10	79.4% FPDs 49.8% FPDs
Schnaidt et al[9] (Germany)	2011	63 CFPDs	Kaplan-Meier	5 10	86.8% FPDs 77.2% FPDs

Additionally, neither patient sex nor dentition in the opposing arch influenced the results, a finding that is largely supported by other studies.[14,24,25] However, two studies showed different results. Schnaidt et al reported a higher survival rate for CFPDs in men after 10 years (86.7%, compared to 72.5% for women). The authors hypothesized that this result occurred because women value esthetics more and considered their restorations to be more critical than men, which led to an increased frequency of denture renewal.[9] Regarding the dentition in the opposing arch, Izikowitz described a significantly worse prognosis ($P < .05$) for patients with a removable complete denture in the opposing arch than that for patients without a denture in this arch.[25]

Conversely, the 22.5% renewal rate and the reasons for the renewals and their continued maintenance align with the data found in the literature.[1,3–5,12,29]

In summary, the results of this study and those found in the literature indicate that CFPDs on vital abutment teeth are not inferior to conventional FPDs and, therefore, are an acceptable treatment alternative. When compared to removable partial dentures, most patients prefer FPDs because of oral comfort, esthetics, and chewing efficiency.[1,14,24,39]

Conclusions

The survival rate of CFPDs on vital and periodontally healthy abutment teeth with a minimum of two-thirds of alveolar bone support is comparable to that of conventional FPDs. Therefore, CFPDs may be considered a good alternative for restoring or partially restoring a shortened dental arch.

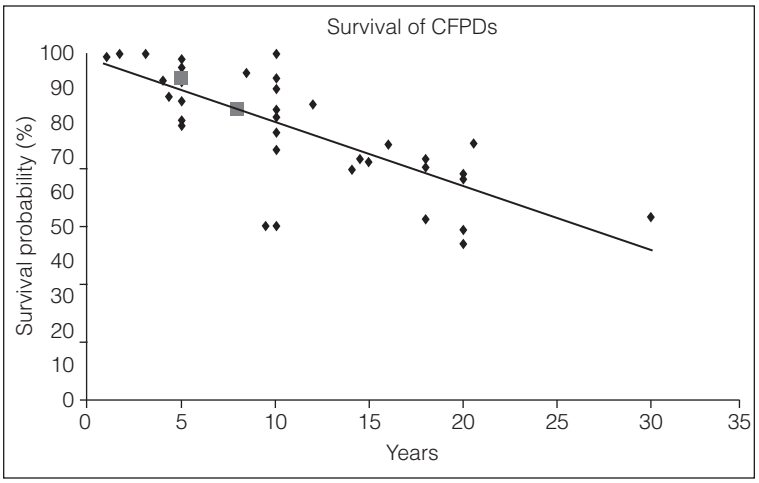

Fig 4 Outcome probability of CFPDs. Black diamonds = data from Table 3; gray squares = results from the present study.

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References

1. Budtz-Jørgensen E, Isidor F. A 5-year longitudinal study of cantilevered fixed partial dentures compared with removable partial dentures in a geriatric population. J Prosthet Dent 1990;64:42–47.
2. Hochman N, Mitelman L, Hadani PE, Zalkind M. A clinical and radiographic evaluation of fixed partial dentures (FPDs) prepared by dental school students: A retrospective study. J Oral Rehabil 2003;30:165–170.
3. Landolt A, Lang NP. Erfolg und Misserfolg bei Extensionsbrücken. [Results and failures in extension bridges. A clinical and roentgenological follow-up study of free-end bridges]. Schweiz Monatsschr Zahnmed 1988;98:239–244.

4. Pjetursson BE, Tan K, Lang NP, et al. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. Clin Oral Implants Res 2004;15:667–676.
5. Decock V, De Nayer K, De Boever JA, Dent M. 18-year longitudinal study of cantilevered fixed restorations. Int J Prosthodont 1996;9:331–340.
6. Hochman N, Ginio I, Ehrlich J. The cantilever fixed partial denture: A 10-year follow-up. J Prosthet Dent 1987;58:542–545.
7. Laurell L, Lundgren D, Falk H, Hugoson A. Long-term prognosis of extensive polyunit cantilevered fixed partial dentures. J Prosthet Dent 1991;66:545–552.
8. Rinke S. Klinische Bewährung von vollkeramischen Extensionsbrücken. 2-Jahres-Ergebnisse. Quintessenz 2006;57:139–146.
9. Schnaidt U, Kahlstorf M, Tschernitschek H. A comparative study of longevity of inlay-retained, cantilever and conventional FPDs. Dtsch Zahnärztl Z 2011;66:348–354.
10. Brägger U, Hirt-Steiner S, Schnell N, et al. Complication and failure rates of fixed dental prostheses in patients treated for periodontal disease. Clin Oral Implants Res 2011;22:70–77.
11. De Backer H, Van Maele G, Decock V, Van den Berghe L. Long-term survival of complete crowns, fixed dental prostheses, and cantilever fixed dental prostheses with posts and cores on root canal-treated teeth. Int J Prosthodont 2007;20:229–234.
12. Hämmerle CH, Ungerer MC, Fantoni PC, et al. Long-term analysis of biologic and technical aspects of fixed partial dentures with cantilevers. Int J Prosthodont 2000;13:409–415.
13. Karlsson S. Failures and length of service in fixed prosthodontics after long-term function. Swed Dent J 1989;13:185–192.
14. Randow K, Glantz PO, Zöger B. Technical failures and some related clinical complications in extensive fixed prosthodontics. An epidemiological study of long-term clinical quality. Acta Odontol Scand 1986;44:241–255.
15. Reichen-Graden S, Lang NP. Periodontal and pulpal conditions of abutment teeth. Status after four to eight years following the incorporation of fixed reconstructions. Schweiz Monatsschr Zahnmed 1989;99:1381–1385.
16. Wolfart S, Harder S, Eschbach S, Lehmann F, Kern M. Four-year clinical results of fixed dental prostheses with zirconia substructures (Cercon): End abutments vs. cantilever design. Eur J Oral Sci 2009;117:741–749.
17. Karlsson S. A clinical evaluation of fixed bridges, 10 years following insertion. J Oral Rehabil 1986;13:423–432.
18. Randow K, Glantz PO. On cantilever loading of vital and nonvital teeth. An experimental clinical study. Acta Odontol Scand 1986;44:271–277.
19. Balkenhol M, Wöstmann B, Rein C, Ferger P. Survival time of cast post and cores: A 10-year retrospective study. J Dent 2007; 35:50–58.
20. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958;53:457–481.
21. Zwiener I, Blettner M, Hommel G. Survival analysis—part 15 of a series on evaluation of scientific publications. Dtsch Arztebl Int 2011;108:163–169.
22. Carlson BR, Yontchev E. Long-term observations of extensive fixed partial dentures on mandibular canine teeth. J Oral Rehabil 1996;23:163–169.
23. Eliasson A, Arnelund CF, Johansson A. A clinical evaluation of cobalt-chromium metal-ceramic fixed partial dentures and crowns: A three- to seven-year retrospective study. J Prosthet Dent 2007;98:6–16.
24. Holm C, Tidehag P, Tillberg A, Molin M. Longevity and quality of FPDs: A retrospective study of restorations 30, 20, and 10 years after insertion. Int J Prosthodont 2003;16:283–289.
25. Izikowitz L. A long-term prognosis for the free-end saddle-bridge. J Oral Rehabil 1985;12:247–262.
26. Leempoel PJ, Käyser AF, Van Rossum GM, De Haan AF. The survival rate of bridges. A study of 1674 bridges in 40 Dutch general practices. J Oral Rehabil 1995;22:327–330.
27. Lindquist E, Karlsson S. Success rate and failures for fixed partial dentures after 20 years of service: Part I. Int J Prosthodont 1998;11:133–138.
28. Öwall BE, Almfeldt I, Helbo M. Twenty-year experience with 12-unit fixed partial dentures supported by two abutments. Int J Prosthodont 1991;4:24–29.
29. Palmqvist S, Swartz B. Artificial crowns and fixed partial dentures 18 to 23 years after placement. Int J Prosthodont 1993; 6:279–285.
30. Pjetursson BE, Brägger U, Lang NP, Zwahlen M. Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). Clin Oral Implants Res 2007;18 (suppl 3):97–113.
31. Sundh B, Ödman P. A study of fixed prosthodontics performed at a university clinic 18 years after insertion. Int J Prosthodont 1997;10:513–519.
32. Yi SW, Ericsson I, Carlsson GE, Wennström JL. Long-term follow-up of cross-arch fixed partial dentures in patients with advanced periodontal destruction. Evaluation of the supporting tissues. Acta Odontol Scand 1995;53:242–248.
33. Yi SW, Carlsson GE, Ericsson I, Wennström JL. Long-term follow-up of cross-arch fixed partial dentures in patients with advanced periodontal destruction: Evaluation of occlusion and subjective function. J Oral Rehabil 1996;23:186–196.
34. Yi SW, Carlsson GE, Ericsson I. Prospective 3-year study of cross-arch fixed partial dentures in patients with advanced periodontal disease. J Prosthet Dent 2001;86:489–494.
35. Sailer I, Pjetursson BE, Zwahlen M, Hämmerle CH. A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part II: Fixed dental prostheses. Clin Oral Implants Res 2007;18 (suppl 3):86–96.
36. Salinas TJ, Eckert SE. In patients requiring single-tooth replacement, what are the outcomes of implant- as compared to tooth-supported restorations? Int J Oral Maxillofac Implants 2007;22 (suppl):71–95.
37. De Backer H, Van Maele G, De Moor N, Van den Berghe L, De Boever J. A 20-year retrospective survival study of fixed partial dentures. Int J Prosthodont 2006;19:143–153.
38. Fayyad MA, al-Rafee MA. Failure of dental bridges. IV. Effect of supporting periodontal ligament. J Oral Rehabil 1997;24: 401–403.
39. Szentpétery AG, John MT, Slade GD, Setz JM. Problems reported by patients before and after prosthodontic treatment. Int J Prosthodont 2005;18:124–130.