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 retention1,4,6,8,10–16 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 teeth3–5,9–12,14,17 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 al5 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 al5) and a preliminary analysis of the survival of posts and cores in fixed restorations18 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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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. 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.

A search for papers published over the past 30 years identified 29 studies\(^1,3,12,17,21–33\) 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

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Number</th>
<th>Statistical method</th>
<th>Observation period (y)</th>
<th>Survival rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Izikowitz25 (Sweden)</td>
<td>1985</td>
<td>69 patients, 67 CFPDs</td>
<td>Kaplan-Meier</td>
<td>5</td>
<td>98% FPDs</td>
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<td></td>
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<td></td>
<td></td>
<td>10</td>
<td>82% FPDs</td>
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<td></td>
<td>15</td>
<td>69% FPDs</td>
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<td></td>
<td>20</td>
<td>49% FPDs</td>
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<tr>
<td>Karlsson17 (Sweden)</td>
<td>1986</td>
<td>164 patients, 238 CFPDs, 944 abutment teeth</td>
<td>Input-output</td>
<td>10</td>
<td>93.3% FPDs</td>
</tr>
<tr>
<td>Randow et al14 (Sweden)</td>
<td>1986</td>
<td>93 FPDs with one cantilever (Group 1), 83 FPDs with two cantilevers (Group 2)</td>
<td>Life table</td>
<td>7</td>
<td>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% periodontal complications</td>
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<tr>
<td>Hochman et al6 (Israel)</td>
<td>1987</td>
<td>27 patients, 29 CFPDs</td>
<td>Input-output</td>
<td>10</td>
<td>100% FPDs</td>
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<tr>
<td>Landolt and Lang3 (Switzerland)</td>
<td>1988</td>
<td>61 patients, 80 CFPDs, 154 abutment teeth (96 vital abutments, 58 nonvital abutments)</td>
<td>Input-output Ø 4, 6</td>
<td>2% failure for vital abutments</td>
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<td></td>
<td>40% failure for nonvital abutments</td>
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<tr>
<td>Karlsson13 (Sweden)</td>
<td>1989</td>
<td>36 CFPDs, 105 abutment teeth</td>
<td>Input-output</td>
<td>14</td>
<td>66.7% FPDs</td>
</tr>
<tr>
<td>Reichen-Graden and Lang15 (Switzerland)</td>
<td>1989</td>
<td>21 CFPDs</td>
<td>Input-output Ø 6, 4</td>
<td>7.4% technical complications</td>
<td></td>
</tr>
<tr>
<td>Budtz-Jørgensen and Isidor1 (Denmark)</td>
<td>1990</td>
<td>27 patients, 41 CFPDs, 79 abutment teeth</td>
<td>Input-output</td>
<td>5</td>
<td>80.5% FPDs</td>
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<td></td>
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<td></td>
<td></td>
<td>98.7% abutments</td>
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<tr>
<td>Laurell et al7 (Sweden)</td>
<td>1991</td>
<td>34 patients, 36 CFPDs</td>
<td>Input-output Ø 8, 4</td>
<td>94.4% FPDs</td>
<td></td>
</tr>
<tr>
<td>Öwall et al28 (Denmark)</td>
<td>1991</td>
<td>11 patients, 11 CFPDs</td>
<td>Input-output 20</td>
<td>45.5% FPDs</td>
<td></td>
</tr>
<tr>
<td>Palmqvist and Swartz29 (Sweden)</td>
<td>1993</td>
<td>34 CFPDs</td>
<td>Input-output 18–23</td>
<td>74.5% FPDs</td>
<td></td>
</tr>
<tr>
<td>Leempoel et al26 (Netherlands)</td>
<td>1995</td>
<td>235 CFPDs</td>
<td>Kaplan-Meier</td>
<td>1</td>
<td>99.6% FPDs</td>
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<td></td>
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<td></td>
<td>5</td>
<td>96.5% FPDs</td>
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<td></td>
<td></td>
<td>10</td>
<td>89.8% FPDs</td>
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<td></td>
<td></td>
<td>12</td>
<td>85.8% FPDs</td>
</tr>
<tr>
<td>Yi et al22,33 (Sweden)</td>
<td>1995</td>
<td>43 FPDs, of which 31 are CFPDs</td>
<td>Input-output Ø 14–15</td>
<td>70% FPDs</td>
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<tr>
<td></td>
<td>1996</td>
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<tr>
<td>Carlson and Yontchev23 (Sweden)</td>
<td>1996</td>
<td>12 patients, 12 CFPDs</td>
<td>Input-output 9.5</td>
<td>50% FPDs</td>
<td></td>
</tr>
<tr>
<td>Decock5 (Belgium)</td>
<td>1996</td>
<td>100 patients, 137 CFPDs</td>
<td>Kaplan-Meier</td>
<td>18</td>
<td>70% FPDs</td>
</tr>
<tr>
<td>Sundh and Ödman31 (Sweden)</td>
<td>1997</td>
<td>31 CFPDs, 98 abutment teeth</td>
<td>Input-output 18</td>
<td>67.7% FPDs</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>63.3% abutments</td>
<td></td>
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<tr>
<td>Lindquist and Karlsson27 (Sweden)</td>
<td>1998</td>
<td>140 FPDs, of which 36 are CFPDs</td>
<td>Life table</td>
<td>20</td>
<td>65.4% FPDs</td>
</tr>
<tr>
<td>Hämmerle et al12 (Switzerland)</td>
<td>2000</td>
<td>92 patients, 115 CFPDs, 239 abutment teeth</td>
<td>Input-output Ø 10</td>
<td>84% FPDs</td>
<td></td>
</tr>
<tr>
<td>Yi et al30 (Korea)</td>
<td>2001</td>
<td>50 FPDs, of which 33 are CFPDs</td>
<td>Input-output 3</td>
<td>100% FPDs</td>
<td></td>
</tr>
<tr>
<td>Holm et al31 (Sweden)</td>
<td>2003</td>
<td>235 patients, 289 FPDs, of which 42 are CFPDs</td>
<td>Life table</td>
<td>10</td>
<td>72% FPDs</td>
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<td>20</td>
<td>64% FPDs</td>
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<td></td>
<td></td>
<td>30</td>
<td>53% FPDs</td>
</tr>
<tr>
<td>Pjetursson et al34 (Switzerland)</td>
<td>2004</td>
<td>Meta-analysis (13 studies, 700 patients, 816 CFPDs)</td>
<td>Input-output 10</td>
<td>81.8% FPDs</td>
<td></td>
</tr>
<tr>
<td>Rinke et al8 (Germany)</td>
<td>2006</td>
<td>21 patients, 26 oxide-ceramic CFPDs (Cercon)</td>
<td>Input-output Ø 1, 7</td>
<td>100% FPDs</td>
<td></td>
</tr>
<tr>
<td>De Backer et al11 (Belgium)</td>
<td>2007</td>
<td>137 CFPDs</td>
<td>Kaplan-Meier</td>
<td>16</td>
<td>73.5% FPDs with vital abutments</td>
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<td></td>
<td></td>
<td>18</td>
<td>52.3% FPDs with nonvital abutments</td>
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</tbody>
</table>

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Additionally, neither patient sex nor dentition in the opposing arch influenced the results, a finding that is largely supported by other studies.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{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.

**Acknowledgments**

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