A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years

IV. Cantilever or extension FPDs

Bjarni E. Pjetursson
Ken Tan
Niklaus P. Lang
Urs Brägger
Matthias Egger
Marcel Zwahlen

Authors’ affiliations:
Bjarni E. Pjetursson, Niklaus P. Lang, Urs Brägger,
School of Dental Medicine, University of Berne,
Berne, Switzerland
Ken Tan, National Dental Center, Singapore,
Singapore
Matthias Egger, Marcel Zwahlen, Division of
Epidemiology and Biostatistics, Department of
Social and Preventive Medicine, University of
Berne, Berne, Switzerland
Matthias Egger, MRC Health Services Research
Collaboration, Department of Social Medicine,
University of Bristol, Bristol, UK

Correspondence to:
Bjarni E. Pjetursson
Department of Periodontology and Fixed
Prosthodontics
University of Berne
Freiburgstrasse 7
CH 3010 Berne
Switzerland
Tel.: +41 31 632 2577
Fax: +41 31 632 4915
e-mail: bjarni.pjetursson@zmk.unibe.ch

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Abstract

Objectives: The objective of this systematic review was to assess the survival of cantilever fixed partial dentures (FPDs) and the incidence of biological and technical complications.

Methods: An electronic MEDLINE search supplemented by manual searching was conducted to identify prospective and retrospective cohort studies on FPDs with a mean follow-up time of at least 5 years. Patients had to have been examined clinically at the follow-up visit. Assessment of the identified studies and data abstraction was performed independently by two reviewers. Failure and complication rates were analyzed using random-effects Poisson regression to obtain summary estimates of 10-year survival proportions.

Results: From a yield of 3658 titles and 211 abstracts, 81 articles were selected for full-text analysis, finally resulting in 13 studies that met the inclusion criteria. Meta-analysis of these studies resulted in an estimated survival rate of cantilever FPDs of 81.8% (95 percent confidence interval (95% CI): 78.2–84.9%) and success rate (free of all complications) of 63% (95% CI: 54.7–70.2%) after 10 years. The most common biological complication was loss of pulp vitality (32.6%) followed by caries at abutment teeth (9.1%). After a 10-year observation period 2.6% of the FPDs were lost as a result of dental caries and 1% due to recurrent periodontitis. The most frequent technical complication was loss of retention (16.1%) followed by material fractures (5.9%). The cumulative incidence of fractures of abutment teeth was 2.9% and 2.4% of the FPDs were lost as a result of abutment tooth fracture after an observation period of 10 years.

Conclusion: This systematic review on cantilever fixed partial dentures indicated that survival and success rates of cantilever fixed partial dentures were lower than those of conventional end-abutment supported FPDs described in a review by Tan et al. (2004) and biological and technical complications were frequent. Cantilever fixed partial dentures [FPDs] have been defined as retainers holding one or more unsupported free-end extensions. Prior to the introduction of dental implants in partially edentulous patients, this type of reconstruction offered a possibility of incorporating fixed reconstructions extending into edentulous areas and was considered a welcome and more favorable alternative to tooth replacement with removable partial dentures.

It has been documented that shortened dental arches or the presence of single or multiple tooth gaps are still compatible
with healthy masticatory function (Käyser 1981; Witter et al. 1988). If, for the replacement of missing teeth in partially edentulous patients, implants were contraindicated due to medical reasons, the presence of jeopardizing anatomical structures or because of the patient’s own concerns, fixed partial dentures in combination with cantilevers are still treatment options to be considered in unbounded edentulous areas.

Clinicians may select a cantilever bridge designs in situations thought to be less demanding regarding occlusal load or where extensions may mainly serve aesthetic aspects. Consequently, the choice of cantilever fixed partial dentures in the reconstruction of partially edentulous patients was rather subjective, and hence prospective or retrospective cohort studies reporting solely on cantilever FPDs are sparse. However, in some studies reporting on fixed partial dentures, results for both conventional and cantilever reconstructions may be retrieved. For example, the study of Karlsson (1989) described a patient cohort that received 36 restoration with cantilever extensions and 103 restorations without in which the survival after an observation period of 14 years was 88.5% for the restorations without cantilever extensions and substantially higher than the 66.7% for the restorations with cantilever extensions.

Studies addressing the longevity of FPDs with cantilever extensions may be divided into two groups: The first group of studies reported on FPDs with one, and in some cases two cantilever extensions. The second group consisted of studies testing the limit’s of the abilities of the tooth-supportive tissues to cope with occlusal load. These reconstructions based on few abutments supporting long extensions, and displayed two to three cantilever units either uni- or bilaterally (Laurell et al. 1991; Öwall et al. 1991; Carlson & Yontchev 1996).

Therefore, the main objective of this systematic review was to obtain robust estimates of the long-term survival rates of cantilever fixed partial dentures and of the incidence of biological and technical complications over an observation period of at least 5 years. Results for conventional end-abutment FPDs have been reviewed and reported elsewhere (Tan et al. 2004).

Materials and methods

Search strategy and study selection

The search strategy was similar to the one used in a systematic review of implant supported FPDs (Pjetursson et al. 2004). Briefly, a MEDLINE [PubMed] search from 1966 up to and including April 2004 was conducted for English-language articles published in the Dental Literature text searching for ‘fixed partial dentures OR bridges’, ‘partial edentulism’.

Manual searches of the bibliographies of all full-text articles and related reviews selected from the electronic search were also performed. Furthermore, manual searching was applied to the following journals for the years 2001–2003: International Journal of Prosthodontics and Journal of Prosthetic Dentistry.

From this extensive search, it was obvious that there were no randomized controlled clinical trials (RCTs) available comparing FPDs with and without cantilever extensions.

Inclusion criteria

In the absence of RCTs, this systematic review is based on prospective or retrospective cohort studies. Additional inclusion criteria for study selection were:

- a mean follow-up time of 5 years or more,
- publications appearing in English and in the Dental literature,
- a prerequisite of clinically examining all included patients at the follow-up visit, i.e., publications based on patient records only, on questionnaires or interviews were excluded from analysis,
- a report with details of the characteristics of the suprastructures incorporated,
- publications that combined findings for both FPDs and single crowns needed to have at least 2/3 of the reconstructions as FPDs.

Study selection

Titles and abstracts were initially screened by two independent reviewers (B.E.P. and K.T.) for possible inclusion in the review. To decide about inclusion of the studies, the full text of all studies of possible relevance was then obtained for independent assessment by the two reviewers. Any disagreement was resolved by discussion amongst the reviewers. Agreement between examiners and reviewers was determined by using κ statistics (Fig. 1).

Figure 1 describes the process of identifying the 13 studies finally included from an initial yield of 1658 titles. Data were extracted independently by two reviewers (B.E.P. and U.B.) using a data extraction form.

Excluded studies

From the 81 full-text articles retrieved, 68 were excluded from the final analysis.

The main reasons for exclusion included a mean observation period of less than 5 years, no specific data available with respect to FPDs and multiple publications on the same patient cohorts.

Data extraction

Information on the survival and success proportions of the reconstructions and of biological and technical complications were retrieved. Survival was defined as the FPDs remaining in situ at the examination visit irrespective of its condition. Success was defined as the FPD that remained unchanged and did not require any intervention during the entire observation period.

Biological complications that were analyzed included caries, loss of pulp vitality and periodontal disease progression.

Technical complications that were analyzed encompassed fractures of the luting cement (loss of retention), abutment tooth fractures and fractures or deformations of the framework or veneers. Form the included studies the number of events for all of these event categories was abstracted, if available, and the corresponding total exposure time was calculated.

Results on conventional FPDs without cantilever extensions have been analyzed separately and reported elsewhere (Tan et al. 2004).

Statistical analysis

By definition, failure and complication rates are calculated by dividing the number of events [failures or complications] in the numerator by the total exposure time [FPD-time and/or abutment-time] in the denominator.

The numerator may usually be extracted directly from the publication. The total
FPDs exposure time were extracted and calculated by different means:

2. From the mean observation time of failed and surviving FPDs (Roberts 1970a, 1970b; Laurell et al. 1991; Sundh & Odman 1997).
3. Using actuarial approximation and information given at fixed observation intervals (Karlsson 1989) in that for failed FPDs the midpoint of minimal and maximal follow-up time was used.
4. The total exposure time was obtained from the original database (Reichen-Graden & Lang 1989; Hämmerle et al. 2000).

The two remaining studies did not report the mean time for surviving FPDs or the times to any specific complications. Therefore, the total exposure time could not be calculated for these studies [Hochman et al. 1987; Palmqvist & Swartz 1993] and they could not be included in the statistical analyses.

For each study, event rates for FPDs and/or abutments were calculated by dividing the total number of events by the total FPDs or abutment exposure time in years. For further analysis, the total number of events was considered to be Poisson distributed for a given sum of FPDs/abutments exposure years, and Poisson regression models with a logarithmic link-function and total exposure time per study as an offset variable were used [Kirkwood & Sterne 2003a, 2003b]. Robust standard errors were calculated to obtain 95% confidence intervals (95% CI) of the summary estimates of the event rates. All analyses were performed using Stata® [Stata Corporation, College Station, TX, USA], Version 8.2.

**Results**

**Included studies**

A total of 13 studies of cantilever FPDs were included in the analysis. The characteristics of the selected studies are shown in Table 1.

These studies were published over a period of three decades, from 1970 to 2000. Three of the studies were prospective and the ten remaining retrospective (Table 1).

The studies included around 700 patients between the age of 26 and 84 years. The proportion of patients with FPDs who could not be followed for the complete study period was available for 9 of the 13 studies and ranged from 0% to 46%. Due to the fact that some of the studies exceeded 10 years observation period, many patients were unable to return due to reasons such as death, chronic illnesses and change of address.

The studies were mainly conducted in an institutional environment, such as a University or a specialized clinic. The operators were dental students, postgraduate students, private dentists and specialists.

In one study, the patients were randomized into a test and a control group to compare mandibular cantilever FPDs with distal extension removable partial dentures (RPDs) [Budtz-Jorgensen & Isidor 1990].

The 13 studies included a total of 816 FPDs. The mean number of cantilever extensions ranged from 1.1 to 6. This information, however, was only available in 7 out of 13 studies [Table 2]. Of the seven studies that reported on bridge design, 72% of the FPDs were of gold-acrylic

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**Fig. 1.** Search strategy.
design and only 28% of a metal–ceramic design (Table 2).

The follow-up time for the cantilever FPDs ranged from 2 to 23 years. The estimated mean follow-up time was 8.2 years (Table 2).

### FPD Survival

FPD survival was defined as the FPD remaining in situ with or without modification for the observation period. Twelve studies provided data on survival of the FPDs (Table 3). From a total of 671 FPDs originally placed, 95 were known to be lost.

The study-specific-estimated 10-year survival varied between 68.3% and 96.7% (Table 3). The estimated annual failure rate per 100 FPD years ranged from 0.33 to 3.81 (Fig. 2). The summary estimate was 2 (95% CI: 1.63–2.46%) (Table 3).

The estimated summary of the survival proportion after 10 years for cantilever FPDs was derived from a standard Poisson regression analysis and was 81.8% (95% CI: 78.2–84.9%) (Table 3).

There was no statistically significant difference when comparing the six studies [Karlsson 1989; Reichen-Graden & Lang 1989; Palmqvist & Swartz 1993; Decock et al. 1996; Sundh & Odman 1997; Hämmelde et al. 2000] reporting on FPDs with one, or occasionally two cantilever extensions, with the three studies [Laurell et al. 1991; Öwall et al. 1991; Carlson & Yontchev 1996] reporting on FPDs with two or three cantilever extensions unilaterally or bilaterally. The group with fewer cantilever extensions had a summary

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**Table 1. Study and patient characteristics of the reviewed studies**

<table>
<thead>
<tr>
<th>Study (year of publication)</th>
<th>Implant system</th>
<th>Sampling method</th>
<th>Study design</th>
<th>Planned no. of patients in study</th>
<th>Actual no. of patients in study</th>
<th>Age range</th>
<th>Mean age</th>
<th>Operator</th>
<th>Dropout (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hämmerle et al. (2000)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>136</td>
<td>92</td>
<td>29–84</td>
<td>56.5</td>
<td></td>
<td>Faculty, postgraduate and dental students</td>
<td>32</td>
</tr>
<tr>
<td>Sundh &amp; Odman (1997)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>52.9</td>
<td></td>
<td>Dental students</td>
<td>15</td>
</tr>
<tr>
<td>Decock et al. (1996)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>131</td>
<td>100</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td>Post- and undergraduate students</td>
<td>24</td>
</tr>
<tr>
<td>Carlson &amp; Yontchev (1996)</td>
<td>Institutional patients</td>
<td>Prospective</td>
<td>12</td>
<td>12</td>
<td>33–74</td>
<td>53</td>
<td></td>
<td>Specialist clinic at University</td>
<td>0</td>
</tr>
<tr>
<td>Palmqvist &amp; Schwartz (1993)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>40</td>
<td>22</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td>Specialist clinic</td>
<td>46</td>
</tr>
<tr>
<td>Laurell et al. (1991)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>34</td>
<td>34</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td>Specialist clinic at University</td>
<td>0</td>
</tr>
<tr>
<td>Öwall et al. (1991)</td>
<td>Institutional patients</td>
<td>Prospective</td>
<td>11</td>
<td>11</td>
<td>26–79</td>
<td>58.5</td>
<td></td>
<td>Specialist clinic</td>
<td>0</td>
</tr>
<tr>
<td>Budtz-Jorgensen &amp; Isidor (1990)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>27</td>
<td>23</td>
<td>61–83</td>
<td>69.7</td>
<td></td>
<td>One specialization</td>
<td>15</td>
</tr>
<tr>
<td>Reichen-Graden &amp; Lang (1989)</td>
<td>Institutional patients</td>
<td>Retrospective</td>
<td>n.a.</td>
<td>15</td>
<td>26–72</td>
<td>49.5</td>
<td></td>
<td>Dental students</td>
<td>n.a.</td>
</tr>
<tr>
<td>Nyman &amp; Lindhe (1979)</td>
<td>Institutional patients with 50% loss of periodontal attachment</td>
<td>Retrospective</td>
<td>n.a.</td>
<td>125</td>
<td>23–72</td>
<td>48.7</td>
<td></td>
<td>Specialist clinic at University</td>
<td>n.a.</td>
</tr>
<tr>
<td>Roberts (1970)</td>
<td>Institutional patients from register</td>
<td>Retrospective</td>
<td>n.a.</td>
<td>29</td>
<td>n.a.</td>
<td>n.a.</td>
<td></td>
<td>Specialist and postgraduate</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

n.a., not available.

---

**Table 2. Information on FPDs in the reviewed studies**

<table>
<thead>
<tr>
<th>Study (year of publication)</th>
<th>Total no. of FPDs</th>
<th>No. of abutments</th>
<th>Mean no. of extensions</th>
<th>Metal/ceramic</th>
<th>Gold/resin</th>
<th>Follow-up range</th>
<th>Mean follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hämmerle et al. (2000)</td>
<td>115</td>
<td>239</td>
<td>1.1</td>
<td>115</td>
<td>0</td>
<td>5–16</td>
<td>10</td>
</tr>
<tr>
<td>Sundh &amp; Odman (1997)</td>
<td>31</td>
<td>n.a.</td>
<td>1.2</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2–18</td>
<td>6</td>
</tr>
<tr>
<td>Decock et al. (1996)</td>
<td>168</td>
<td>n.a.</td>
<td>6.0</td>
<td>n.a.</td>
<td>11</td>
<td>16–20</td>
<td>18</td>
</tr>
<tr>
<td>Carlson &amp; Yontchev (1996)</td>
<td>34</td>
<td>n.a.</td>
<td>1.3</td>
<td>n.a.</td>
<td>32</td>
<td>5–12</td>
<td>8.4</td>
</tr>
<tr>
<td>Palmqvist &amp; Schwartz (1993)</td>
<td>36</td>
<td>166</td>
<td>3.7</td>
<td>4</td>
<td>11</td>
<td>5–10</td>
<td>9.5</td>
</tr>
<tr>
<td>Laurell et al. (1991)</td>
<td>11</td>
<td>22</td>
<td>6.0</td>
<td>0</td>
<td>27</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Öwall et al. (1991)</td>
<td>27</td>
<td>79</td>
<td>n.a.</td>
<td>0</td>
<td>159</td>
<td>5–8</td>
<td>6.2</td>
</tr>
<tr>
<td>Budtz-Jorgensen &amp; Isidor (1990)</td>
<td>21</td>
<td>n.a.</td>
<td>2.2</td>
<td>0</td>
<td>137</td>
<td>n.a</td>
<td>5.1</td>
</tr>
<tr>
<td>Reichen-Graden &amp; Lang (1989)</td>
<td>36</td>
<td>105</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>4–8</td>
<td>6.2</td>
</tr>
<tr>
<td>Karlsson (1989)</td>
<td>29</td>
<td>91</td>
<td>n.a.</td>
<td>n.a.</td>
<td>14</td>
<td>n.a</td>
<td>14</td>
</tr>
<tr>
<td>Hochman et al. (1987)</td>
<td>159</td>
<td>n.a.</td>
<td>2.2</td>
<td>0</td>
<td>159</td>
<td>5–10</td>
<td>n.a.</td>
</tr>
<tr>
<td>Nyman &amp; Lindhe (1979)</td>
<td>137</td>
<td>n.a.</td>
<td>0.0</td>
<td>0</td>
<td>137</td>
<td>n.a</td>
<td>5.1</td>
</tr>
<tr>
<td>Total</td>
<td>816</td>
<td>140</td>
<td>366</td>
<td>8.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FPDs, fixed partial dentures; n.a., not available.
estimate of the survival proportion after 10 years of 81% [95% CI: 77–84.3%], compared with a survival estimate of 79.4% [95% CI: 51–92.4%] for the FPDs with multiple cantilever extensions.

The studies were also divided according to the veneer material utilized: A group of two studies with a total of 136 FPDs with ceramics as a veneer material and a group of four studies with a total of 211 FPDs with acrylic veneers were available for analysis. The group with metal ceramic FPDs had a summary estimate of the survival proportion after 10 years of 85% [95% CI: 81.4–87.9%], compared with a survival proportion of 84.9% [95% CI: 75.1–91.1%] for the gold–crylic FPDs.

Success
Success was defined as an FPD being free of all complications over the entire observation period. Four [Budtz-Jorgensen & Isidor 1990; Palmqvist & Schwartz 1993; Carlson & Yontchev 1996; Decock et al. 1996] out of 13 studies reported how many patients were free of any complications. For two studies [Reichen-Graden & Lang 1989; Hammerle et al. 2000], this information could be extracted from the original database.

These six studies included a total of 391 FPDs from which 119 had some complications over the observation period. The study-specific-estimated 10-year success proportion varied between 38.6% and 73.5% [Table 4].

The summary estimate of the success proportion after 10 years was 63% [95% CI: 54.7–70.2%] [Table 4] or, in other terms, 37% of the patients had some minor or major complications over 10 years' observation period.

Biological complications
Dental caries
Caries were reported at the abutment and at the FPD levels.

Three studies with a total of 305 abutments gave information on caries occurring at the abutments. The annual complication rate ranged between 0.77% and 2.38%. In random-effects Poisson model analysis, the estimated cumulative rate of caries occurring at abutments over an observation period of 10 years was 9.1% [95% CI: 6.3–13%] [Table 5].

Caries leading to the loss of the FPD was addressed in six studies. Eleven of the 511 FPDs were lost as a result of caries. The annual FPD failure rate ranged between 0% and 0.77%. In a standard Poisson model analysis, the estimated cumulative rate of FPDs lost due to caries after 10 years was 2.6% [95% CI: 0.7–9.9%] [Table 5].

Loss of abutment vitality
Loss of abutment vitality was reported in three studies. Twenty-eight out of 155

Table 3. Annual failure rate and survival of cantilever FPDs

<table>
<thead>
<tr>
<th>Study (year of publication)</th>
<th>Total no. of FPDs</th>
<th>Mean follow-up time</th>
<th>No. of failures</th>
<th>Total FPDs exposure time</th>
<th>Estimated failure rate (per 100 FPD years)</th>
<th>Estimated survival after 10 years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hammerle et al. (2000)</td>
<td>115</td>
<td>10</td>
<td>18</td>
<td>1035</td>
<td>1.74</td>
<td>84</td>
</tr>
<tr>
<td>Sundh &amp; Odman (1997)</td>
<td>31</td>
<td>18</td>
<td>10</td>
<td>488</td>
<td>2.05</td>
<td>81.5</td>
</tr>
<tr>
<td>Decock et al. (1996)</td>
<td>168</td>
<td>6</td>
<td>20</td>
<td>782</td>
<td>2.56</td>
<td>77.4</td>
</tr>
<tr>
<td>Carlson &amp; Yontchev (1996)</td>
<td>12</td>
<td>9.5</td>
<td>4</td>
<td>105</td>
<td>3.81</td>
<td>68.3</td>
</tr>
<tr>
<td>Palmqvist &amp; Schwartz (1993)</td>
<td>34</td>
<td>18-23</td>
<td>8</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Laurell et al. (1991)</td>
<td>36</td>
<td>8.4</td>
<td>1</td>
<td>300</td>
<td>0.33</td>
<td>96.7</td>
</tr>
<tr>
<td>Owall et al. (1991)</td>
<td>11</td>
<td>18</td>
<td>5</td>
<td>147</td>
<td>3.4</td>
<td>71.2</td>
</tr>
<tr>
<td>Budtz-Jorgensen &amp; Isidor (1990)</td>
<td>41</td>
<td>5</td>
<td>2</td>
<td>196</td>
<td>1.02</td>
<td>90.3</td>
</tr>
<tr>
<td>Reichen-Graden &amp; Lang (1989)</td>
<td>21</td>
<td>6.2</td>
<td>1</td>
<td>130</td>
<td>0.77</td>
<td>92.6</td>
</tr>
<tr>
<td>Karlsson (1989)</td>
<td>36</td>
<td>14</td>
<td>12</td>
<td>454</td>
<td>2.64</td>
<td>76.8</td>
</tr>
<tr>
<td>Hochman et al. (1987)</td>
<td>29</td>
<td>5-10</td>
<td>0</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Roberts (1970)</td>
<td>137</td>
<td>5.1</td>
<td>14</td>
<td>704</td>
<td>1.99</td>
<td>82</td>
</tr>
<tr>
<td>Total</td>
<td>671</td>
<td></td>
<td>95</td>
<td>4341</td>
<td>2 (1.63–2.46)</td>
<td>81.8 (78.2–84.9)</td>
</tr>
</tbody>
</table>

*Based on standard Poisson regression, test for heterogeneity P = 0.23. FPDs, fixed partial dentures; n.a., not available; CI, confidence interval.

Fig. 2. Annual failure rates [per 100 cantilever fixed partial dentures].
abutment teeth considered vital at the time of cementation presented with loss of pulp vitality over the observation period. The annual abutment complication rate ranged between 1.1% and 9%. Two studies [Öwall et al. 1991; Carlson & Yontchev 1996] reporting on twelve-unit FPDs in the mandible supported by two canines only showed substantially higher annual complication rates (3.5% and 9%) than the study reporting on FPDs with on average 1.1 cantilever extensions [Hämmerle et al. 2000].

In random-effects Poisson model analysis, the estimated cumulative rate of vital abutments that lost pulp vitality over a 10-year observation period was 32.6% (95% CI: 13.9–64.9%) (Table 5).

Recurrent periodontitis
Seven studies provided information on periodontal disease progression resulting in loss of the entire reconstruction (Table 5), and three out of 395 FPDs were lost due to recurrent periodontitis in these studies.

In standard Poisson model analysis, the estimated cumulative rate of FPDs lost due to recurrent periodontitis over a 10-year observation period was 1% (95% CI: 0.3–3%) (Table 5).

Technical complications
Loss of retention (fracture of the luting cement)
Loss of retention of the reconstructions (Table 6) were addressed in seven studies, and affected 49 out of 404 FPDs. The annual FPD complication rate ranged between 0.3% and 5.7%. The highest annual

<table>
<thead>
<tr>
<th>Study (year of publication)</th>
<th>Total no. of FPDs</th>
<th>Mean follow-up time</th>
<th>No. of complications</th>
<th>Total FPDs exposure time</th>
<th>Estimated complication rate (per 100 FPD years)</th>
<th>Estimated success after 10 years (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hämmerle et al. (2000)</td>
<td>115</td>
<td>10</td>
<td>39</td>
<td>1035</td>
<td>3.77</td>
<td>68.6</td>
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<tr>
<td>Decock et al. (1996)</td>
<td>168</td>
<td>6</td>
<td>41</td>
<td>741</td>
<td>5.53</td>
<td>57.5</td>
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<tr>
<td>Carlson &amp; Yontchev (1996)</td>
<td>12</td>
<td>9.5</td>
<td>10</td>
<td>105</td>
<td>9.52</td>
<td>38.6</td>
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<tr>
<td>Budtz-Jorgensen &amp; Isidor (1990)</td>
<td>41</td>
<td>5</td>
<td>8</td>
<td>196</td>
<td>4.08</td>
<td>66.5</td>
</tr>
<tr>
<td>Reichen-Graden &amp; Lang (1989)</td>
<td>21</td>
<td>6.2</td>
<td>4</td>
<td>130</td>
<td>3.08</td>
<td>73.5</td>
</tr>
<tr>
<td>Total</td>
<td>391</td>
<td>119</td>
<td>2207</td>
<td></td>
<td>4.62 (3.54–6.04)</td>
<td>63 (54.7–70.2)</td>
</tr>
</tbody>
</table>

Based on standard Poisson regression, test for heterogeneity $P = 0.06$.

FPDs, fixed partial dentures; n.a., not available; CI, confidence interval.

<table>
<thead>
<tr>
<th>Study (year of publication)</th>
<th>Mean follow-up time</th>
<th>Total no. of vital abutments</th>
<th>Total abutment exposure time</th>
<th>Estimated rate of loss of vitality (per 100 abutment years)</th>
<th>Total no. of abutments</th>
<th>Total abutment exposure time</th>
<th>Estimated rate of caries of abutments (per 100 abutment years)</th>
<th>Total no. of FPDs</th>
<th>Total FPDs exposure time</th>
<th>Estimated rate of FPDs lost due to caries (per 100 FPD years)</th>
<th>Estimated rate of FPDs lost due to periodontitis (per 100 FPD years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hämmerle et al. (2000)</td>
<td>10</td>
<td>120</td>
<td>1080</td>
<td>1.11</td>
<td>239</td>
<td>2151</td>
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<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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<td>1.12</td>
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<td>8.97</td>
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<td>210</td>
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<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
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<tr>
<td>Budtz-Jorgensen &amp; Isidor (1990)</td>
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<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>41</td>
<td>195</td>
<td>n.a.</td>
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</tr>
<tr>
<td>Reichen-Graden &amp; Lang (1989)</td>
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<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>42</td>
<td>260</td>
<td>0.77</td>
<td>21</td>
<td>130</td>
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<td>0</td>
</tr>
<tr>
<td>Nyman &amp; Lindhe (1979)</td>
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<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>193</td>
<td>1197</td>
<td>0</td>
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<tr>
<td>Summary estimate event rates</td>
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<td></td>
<td>3.95*</td>
<td>0.95†</td>
<td>0.31†</td>
<td>0.1†</td>
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<tr>
<td>Cumulative 10-year complication rates (95% CI)</td>
<td></td>
<td></td>
<td></td>
<td>32.6%* (13.9–64.9%)</td>
<td>9.1%† (6.3–13%)</td>
<td>3.1%† (1–8.8%)</td>
<td>1%† (0.3–3%)</td>
<td></td>
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</tr>
</tbody>
</table>

Based on random-effects Poisson regression.

Based on standard Poisson regression.

FPDs, fixed partial dentures; n.a., not available; CI, confidence interval.
Material complications: framework, veneer and core fractures
Six studies reported on the occurrence of material complications. These included fractures of the framework, the veneers or the core build-ups. Twenty of the 510 FPDs were affected by material complications.

The annual FPD material fracture rate ranged between 0% and 2% (Table 6). The highest annual rate of material complication was reported for the 12-unit FPDs in the mandible supported by two canines only (Öwall et al. 1991).

In a random-effect Poisson model analysis, the estimated cumulative rate of material complications over a 10-year observation period was 5.9% (95% CI: 3.3–10.4%).

**Discussion**

This systematic review is part of a series of reviews addressing the survival and complication rates of FPDs of different designs. This review was performed to evaluate the evidence available for cantilever-fixed FPDs and to compare this treatment option with conventional FPDs.

No RCTs were available comparing conventional FPDs with cantilever FPDs. RCTs comparing these two treatment modalities will probably never be conducted due to different indications chosen for conventional and cantilever FPDs. In the absence of RCTs, a lower level of evidence, i.e., prospective and retrospective cohort studies, were included in this systematic review in order to evaluate the available information on both survival and complication rates of cantilever FPDs after a period of at least 5 years.

Prior to the use of dental implants, cantilever FPDs offered the only possibility to extend a shortened dental arch with a fixed reconstruction. Cantilever FPDs are still indicated in such situations if oral implants cannot be used due to medical reasons, the presence of jeopardizing anatomical structures or because of patients-centered factors such as financial concerns. Hence, the comparison of survival and complications rates of cantilever FPDs with those of conventional FPDs or implant-supported FPDs is of great prognostic value in treatment planning.

Three studies (Karlsson & Swartz 1993; Sundh & Odman 1997) include both conventional FPDs and cantilever FPDs within the same patient cohort. One of these study reported higher proportions of failures for the cantilever FPDs. After 14 years observation period, 12 out of 104 or 12% of the conventional FPDs were lost, compared with 12 out of 36 or 33% of the cantilever FPDs. It has to be realized.
that this difference was mainly due to failures that occurred between 8 and 14 years of service, while up to 8 years no significant difference in cumulative failure rates were observed.

The two other studies reported no difference of failure rates between the two FPD designs. In the former study, eight out of 34 or 24% of the cantilever FPDs were lost compared to 16 out of 69 or 23% of the conventional FPDs 18–23 years after placement (Palmqvist & Swartz 1993). The latter study reported, after a follow-up period of 18 years, no difference in the removal frequencies of FPDs with cantilever extensions compared with the removal frequencies of conventional FPDs (Sundh & Odman 1997).

In this systematic review, a large number of longitudinal cohort studies with a mean follow-up time of at least 5 years were reviewed regarding survival of cantilever FPDs and their biological and technical complications. Survival was defined as the FPD remaining in situ with or without modification for the entire observation period.

The present search targeted to identify long-term cohort studies that reported specifically on cantilever FPDs. When titles and abstracts did not provide sufficient information on study duration and whether or not information on the suprastructures was provided, a full-text analysis of the articles was carried out.

From the 13 studies meeting the inclusion criteria of the systematic review, six reported on cantilever FPDs with one or occasionally two cantilever extensions. Four studies reported on FPDs with multiple cantilever extensions. The remaining three studies did not give information on number of cantilever extensions.

The cumulative failure rate of the cantilever FPDs was 18.2% after a 10-year follow-up time. Compared with the results of a systematic review on conventional end-abutment-supported FPDs (Tan et al. 2004), there was a clearly higher cumulative failure rate (18.2% vs. 10.9%) after 10 years for the cantilever FPDs. This in turn, indicates that cantilever FPDs present higher clinical risk than conventional FPDs.

Surprisingly, there was no significant difference comparing cantilever FPDs with mainly one cantilever pontic and cantilever FPDs with multiple cantilever extensions. In spite of the relatively small number of reconstructions, the survival of this extreme form of treatment with up to six cantilever units confirms the ability of the periodontal ligament to withstand heavy occlusal load. Moreover, there was no significant difference, comparing FPDs with ceramic as veneer material from cantilever FPDs with acrylic veneers.

In a study by Karlsson [1989], two-thirds (67%) of the failed cantilever FPDs had a terminal root canal-treated abutment. The results indicated that cantilever FPDs were more prone to failure, if they based on a non-vital terminal abutment. Increased problems with non-vital abutment teeth have also been reported in other studies [Decock et al. 1996; Sundh & Odman 1997; Hämmerle Glantz 2000]. An experimental study [Randow & Glantz 1986] was performed on three patients using buccal bars attached to crowns on vital and non-vital teeth with various loads applied to them. The pain threshold was found to be almost twice as high on root-canal-treated teeth as compared to vital teeth. The authors concluded that cantilever loading may account for the higher failures associated with devitalized teeth, since the pain tolerance was significantly higher for non-vital compared to vital abutments. They also found that when vital teeth were anesthetized, the pain threshold increased to that of the non-vital teeth. In essence, this confirms the notion that cantilever FPDs should only be chosen if the abutments consist of vital teeth.

The incidence of biological complications was reported both on abutment and FPD levels.

The most common biological complication was loss of pulp vitality occurring in 32.6% of abutment teeth considered vital at the time of cementation over 10 years. This high proportion was mainly due to the very high annual complication rates of the two studies [Öwall et al. 1991; Carlson & Yontchev 1996] reporting on 12-unit cantilever FPDs in the mandible supported by two canines only. The increased incidences of loss of vitality for these studies had been attributed to the periodontal conditions of the patients who were described as ‘non-optimal’. The role of increased occlusal loads was also mentioned as a presumptive contributory factor.

The third study addressing loss of pulp vitality [Hämmerle et al. 2000] reported that 12 out of originally 120 vital abutment teeth or 10% lost their vitality over 10 years.

The second most common biological complication was caries at abutments teeth [9.1% over 10 years]. Nevertheless, only 2.6% of the FPDs were lost as a result of dental caries. An association between loss of retention and secondary caries was noted in several studies. In one study [Hämmerle et al. 2000], 12 out of 19 abutments that lost retention were also diagnosed with caries lesions. Moreover, 12 out of 18 abutments with caries lesions exhibited loss of retention. It may be debated which of the two conditions occurred first and led to the other.

Rarely encountered biological complications included loss of FPDs due to recurrent periodontitis [1% over 10 years]. Four out of seven studies addressing this complication did not report a single FPD lost as result of recurrent periodontitis. It has to be kept in mind that all these studies were conducted in an institutional environment where the patients are usually well maintained and comply with a recall system.

The incidence of technical complications was also reported both on abutment and FPD levels.

The most frequent technical complication was loss of retention. This complication was reported for 18% of the FPDs after an observation period of 10 years. The second most frequent technical complication was fracture of material. These included fractures of framework, veneers and cores and occurred in 5.9% of the FPDs over 10 years. These complications were most frequent in FPDs with multiple cantilever extensions.

On the abutment level, the incidence of fractures of abutment teeth was 2.9% and 2.6% of the FPDs were lost as result of abutment tooth fracture after an observation period of 10 years.

In recognition of the different biomechanical demands for cantilever FPDs, various occlusal schemes have been advocated.

Recommendations for the occlusion of cantilever bridges were ‘freedom’ in the retrusive/protrusive range, anterior-guided lateral movements and the absence of non-working side contacts on the cantilever units [Laurell et al. 1991]. Optimal reten-
Conflicts of interest

Berne, Switzerland. Promotion of Oral Health, University of Research Foundation (CRF) for the has been supported by the Clinical

L’objectif de cette revue systématique a été de vérifier la survie des prothèses fixées avec extension et l’incidence des complications biologiques et techniques. Une recherche Medline ainsi que manuelle de rétrospective et prospectifs acerca de FPDs con un tiempo de seguimiento medio de al menos 5 años. Los pacientes tenían que haber sido examinados clínicamente en la visita de seguimiento. La valoración de los estudios encontrados y de la abstracción de datos se llevó a cabo independientemente por dos revisores. Los índices de fracaso y complicación se analizaron usando modelos de regresión de efectos aleatorios de Poisson para obtener estimaciones de los sumarios de las proporciones de supervivencia a los 10 años.

Resumen

Objective: El objetivo de esta revisión sistemática fue valorar la supervivencia de dentaduras parciales fijas (FPDs) en extension y la incidencia de complicaciones biológicas y técnicas.

Métodos: Se llevó a cabo una búsqueda electrónica por Medline complementada con una búsqueda manual para identificar estudios cohorte prospectivos y retrospectivos acerca de FPDs con un tiempo de seguimiento medio de al menos 5 años. Los pacientes tenían que haber sido examinados clínicamente en la visita de seguimiento. La valoración de los estudios encontrados y de la abstracción de datos se llevó a cabo independientemente por dos revisores. Los índices de fracaso y complicación se analizaron usando modelos de regresión de efectos aleatorios de Poisson para obtener estimaciones de los sumarios de las proporciones de supervivencia a los 10 años.

Resultados: De un total de 3658 títulos y 211 resúmenes, se seleccionaron 81 artículos para análisis completo del texto, resultando finalmente en 13 estudios coincidieron con los criterios de inclusión. Un meta análisis de estos estudios resultó en un índice estimado de supervivencia de FPDs con extensiones del 81.8% (IC95%:78.2–84.9%) y un índice de fracaso [libre de cualquier complicación] del 63% (IC95%: (44.7–70.2%) tras 10 años. La complicación biológica más frecuente fue la pérdida de vitalidad pulpar (32.6%) seguido por la caries en los dientes pilares (9.1%). Tras un período de observación de 10 años un 2.6% de los FPDs se perdieron como resultado de caries dental y 1% debido a periodontitis recurrente. La complicación técnica más frecuente fue la pérdida de retención (16.1%) seguida por fractura de los materiales (5.9%). La incidencia acumulativa de fracturas en los dientes pilares fue del 2.9% y el 2.4% de los FPDs se perdió como resultado de la fractura del diente pilar tras un período de observación de 10 años.

Conclusion: Esta revisión sistemática sobre dentaduras parciales fijas en extensión indicó que los índices de supervivencia y éxito de las dentaduras parciales fijas en extensión fue menor que aquellos de FPDs soportados por pilar final convencional descripto por una revisión por Tan et al. (2004) y las complicaciones biológicas y técnicas fueron frecuentes.

要旨

目的: 本研究的目的是, カンチレーテ型固定備用義歯 (FPD) の生存率を評価し, 生物学的及び技術的合併症の発症率を検討することで行われた。

方法: 人工データ及びMedline検索を行い, 少なくとも5年間の平均観察期間をもつFPDに関する方向及び脱落に関するコホート調査を選択した。患者は検査後1年間の臨床的な検査を受けていたことを条件とした。選出した研究の評価とデータ
References


