Survival and complication rates of implant-supported fixed partial dentures with cantilevers: a systematic review

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Conflicts of interest:
The authors declare no conflicts of interest.

Key words: cantilever extensions, complications, fixed partial dental prosthesis, implant-supported, survival, systematic review

Abstract

Objective: The objective of the present systematic review was to analyze the potential effect of incorporation of cantilever extensions on the survival rate of implant-supported fixed partial dental prostheses (FPDPs) and the incidence of technical and biological complications, as reported in longitudinal studies with at least 5 years of follow-up.

Methods: A MEDLINE search was conducted up to and including November 2008 for longitudinal studies with a mean follow-up period of at least 5 years. Two reviewers performed screening and data abstraction independently. Prosthesis-based data on survival/failure rate, technical complications (prosthesis-related problems, implant loss) and biological complications (marginal bone loss) were analyzed.

Results: The search provided 103 titles with abstract. Full-text analysis was performed of 12 articles, out of which three were finally included. Two of the studies had a prospective or retrospective case-control design, whereas the third was a prospective cohort study. The 5-year survival rate of cantilever FPDPs varied between 89.9% and 92.7% (weighted mean 91.9%), with implant fracture as the main cause for failures. The corresponding survival rate for FPDPs without cantilever extensions was 96.3–96.2% (weighted mean 95.8%).

Technical complications related to the supra-constructions in the three included studies were reported to occur at a frequency of 13–26% (weighted mean 20.3%) for cantilever FPDPs compared with 0–12% (9.7%) for non-cantilever FPDPs. The most common complications were minor porcelain fractures and bridge-screw loosening.

For cantilever FPDPs, the 5-year event-free survival rate varied between 66.7% and 79.2% (weighted mean 71.7%) and between 83.1% and 96.3% (weighted mean 85.9%) for non-cantilever FPDPs.

No statistically significant differences were reported with regard to peri-implant bone-level change between the two prosthetic groups, either at the prosthesis or at the implant level.

Conclusion: Data on implant-supported FPDPs with cantilever extensions are limited and therefore survival and complication rates should be interpreted with caution. The incorporation of cantilevers into implant-borne prostheses may be associated with a higher incidence of minor technical complications.

The selection of prosthetic options to replace missing teeth should be based on scientific evidence. The incorporation of cantilever extensions into implant-borne reconstructions may be considered as an option in situations where local conditions of the residual edentulous ridge preclude the possibility to place an implant. However, it has been claimed that cantilever extensions increase the risk of bending...
overload and that this in turn may compromise the prognosis of the prosthetic rehabilitation (Rangert et al. 1995). In a series of recent systematic reviews, the information available in the literature on the success/survival rates and the incidence of biological and technical complications of different designs of tooth and implant-supported fixed prosthesis was summarized (Lang et al. 2004; Pietreusson et al. 2004a, 2004b, 2007; Tan et al. 2004; Jung et al. 2008; Pietreusson & Lang 2008). These reviews revealed that the incidence of technical complications was significantly higher for implant-supported than for tooth-supported prostheses. For tooth-supported prostheses, technical complications were found to be more frequent for cantilever than for end-abutment prostheses. However, the extent to which cantilevers may affect the survival and complication rates of implant-supported fixed dental prostheses (FDPs) was not analyzed in these reviews.

Long-term clinical studies have demonstrated that implant-supported full-arch reconstructions with bilateral cantilevers in the mandible exhibited high survival rates [Adell et al. 1981, 1990; Albrektsson et al. 1988]. However, it has been suggested that certain cantilever lengths may decrease the survival of the prostheses (Shackleton et al. 1994). There are inherent biomechanical differences in the implant treatment of completely edentulous arches and posterior partially edentulous segments, as the partial prosthesis does not benefit from cross-arch stabilization and, therefore, is more susceptible to bending loads (Rangert et al. 1997).

In vitro studies revealed that implant-supported cantilever prostheses lead to a high stress concentration at the marginal bone level of the implants, particularly at the implant closest to the cantilever extension [Sertoglu & Guvenen 1996; Stegaroiu et al. 1998; Zampelis et al. 2007], which was considered to pose a risk for marginal bone loss at the implants. On the other hand, experimental studies in the dog model showed that excessive static loading of implants did not result in marginal bone loss or loss of osseointegration, but that the bone tissue adjacent to the loaded implants exhibited a greater density compared with unloaded implants [Gotfredsen et al. 2001a, 2001b]. Implant loss as a result of excessive occlusal load in a lateral direction was demonstrated in experimental studies in a monkey model [Isidor 1996, 1997], suggesting that it is possible to induce loss of osseointegration to the implant, but not marginal bone loss, when forces are beyond the repair potential of the bone. However, in humans, the biological impact of excessive load remains unclear.

The focus question for the current systematic review was ‘To what extent do cantilevers affect survival and complications of implant-borne reconstructions in the partially dentate patient’. Hence, the aims defined were to analyze the potential effect of the incorporation of cantilever extensions on (i) the survival (or failure) rate of implant-supported fixed partial dental prostheses (FPDPs) and (ii) the incidence of technical and biological complications, as reported in longitudinal studies with at least 5 years of follow-up.

Materials and methods

Search strategy
A protocol to be followed was agreed upon by the authors before the initiation of the literature search. Anticipating very few, if any, randomized clinical trials [RCT] related to the focused topic, the decision was taken to use a broad search strategy.

An initial electronic search on MEDLINE [PubMed] from 1966 up to and including November 2008 was conducted for English-language articles published in the dental literature, using the keywords ‘dental implants’ AND ‘cantilever[s]’. The search yielded 103 references to be screened for possible inclusion based on titles and abstracts.

Inclusion criteria
Systematic reviews and longitudinal prospective/retrospective studies [RCT, controlled clinical trials and cohort studies] reporting data with regard to the outcome of treatment with implant-supported FPDPs with cantilever extensions after a mean function time of at least 5 years were accepted for inclusion. The selection of a function time of at least 5 years was based on the consensus from a previous workshop regarding the recommended follow-up time for evaluation of implant therapy [Wennstrom & Palmer 1999]. Further, the studies should include prosthesis-based data on success, survival or loss rate, technical complications [prosthesis-related problems, implant loss] and/or biological complications [marginal bone loss].

Exclusion criteria
Letters, experimental studies and narrative reviews were explicitly excluded. Studies with < 10 patients examined at the end of follow-up, and studies focusing on overdentures were also excluded. Studies from which data on selected outcome variables could not be directly retrieved or calculated were not considered.

Selection of studies
Two independent reviewers [JZ and CR] screened the 103 abstracts retrieved from the electronic search for possible inclusion in the review. Ten abstracts were accepted for inclusion by both reviewers, and further three by just one reviewer. After discussion, a consensus was reached to include one of the latter publications and reject the other two articles. The Kappa score for agreement between the reviewers for screening of abstracts was 0.85 (Fig. 1). Full-text articles were obtained of the 11 selected publications. In addition, hand searches were performed on bibliographies of the selected articles as well as of identified narrative reviews. Four publications were found that reported data on subject samples that were included in the already identified studies. Such repeated reports were grouped together. One further article was identified for inclusion after the hand search.

The two reviewers independently assessed the 12 full-text articles to determine whether they fulfilled the defined criteria for final inclusion. Any disagreement was resolved by discussion. Three studies were found to qualify for inclusion in the review, while nine studies had to be excluded (Fig. 1).

Excluded studies
Out of the nine studies that were excluded following full-text analysis, seven had a mean follow-up less than 5 years, including two studies focusing on complete FPDPs, and in further two studies selected outcomes could not be retrieved [Table 1].

Data extraction
Data were extracted independently by the two reviewers using a data extraction form
previously agreed upon. Disagreement regarding data extraction was resolved by discussion and consensus. The following variables were recorded:

- Number of subjects included at baseline and at the follow-up examination; number and characteristics of the FPDPs; extension of cantilever segment (mm or crown units); implant system used, number and length of implants involved in the FPDPs; and type of antagonist dentition.
- Technical complications were divided into three categories:
  
  i. Lost reconstructions i.e. reconstructions not in situ at the follow-up examination.
  
  ii. Lost implants (including reasons for the loss).
  
  iii. Complications related to the superstructure – fractures or deformations of the framework or veneers, loss of retention and screw or abutment loosening.
- Biological complications – marginal bone loss at the FDP level and at the implant next to the cantilever, respectively.

Studies in which data on a certain variable were lacking or could not be calculated were scored as ‘not reported’ for the variable in question. Weighted mean values and the 95% confidence interval (CI) for the various outcomes were calculated.

Results

The literature search confirmed the inexistence of publications on RCT comparing the outcomes of implant-supported FPDPs with and without cantilever extensions.

Characteristics of the included studies (Table 2)

The study characteristics of the three publications that qualified for inclusion [Wennström et al. 2004; Kreissl et al. 2007; Hälg et al. 2008] are presented in Table 2. Two of the studies had a prospective or a retrospective case–control design, whereas the third was a prospective cohort study. In one study [Wennström et al. 2004] all included patients had a 5-year follow-up, whereas in the other two studies the follow-up time among the patients ranged between 0 and 12.7 years, with a reported mean follow-up time of 5.5–7.3 years.

The implant systems used in the studies were ITI (Straumann AG, Waldenburg, Switzerland, one study), Astra (Astra Tech AB, Mölndal, Sweden, one study) and 3i (Implant Innovation Inc., West Palm Beach, FL, USA, one study).
Table 2. Characteristics of the included studies

<table>
<thead>
<tr>
<th>Reference</th>
<th>Type of study</th>
<th>Number of patients</th>
<th>Implant system</th>
<th>Follow-up period in years (range)</th>
<th>Number of reconstructions</th>
<th>Mean number of implants in prosthesis</th>
<th>Mean length of implants (range)</th>
<th>Cantilever extension</th>
<th>Type of antagonists</th>
<th>Comments</th>
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<tr>
<td>Case–control studies</td>
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<tr>
<td>Hägl et al. (2008)</td>
<td>Retrospective</td>
<td>54</td>
<td>ITI</td>
<td>Mean 5.3 years (3–12.7)</td>
<td>Cant: 27</td>
<td>Cant: 1.7 Non-C: 1.2 10.1 mm (6–12)</td>
<td>1 crown unit (26 prostheses) 2 crown units (1 prosthesis)</td>
<td>Teeth or FPDPs on teeth</td>
<td>Cantilever group, 52% and 81%, respectively.</td>
<td></td>
</tr>
<tr>
<td>Wennström et al. (2004)</td>
<td>Prospective</td>
<td>45</td>
<td>Astra Tech</td>
<td>5 years</td>
<td>Cant: 24</td>
<td>Cant: 2.6 Non-C: 2.8 12.7 mm (8–19 mm)</td>
<td>Mean 9 mm</td>
<td>Teeth or FPDPs on teeth except 1 (implant-supported FPDP)</td>
<td></td>
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<tr>
<td>Cohort studies</td>
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<td></td>
<td></td>
<td>Cant: 23</td>
<td>Cant: 2.7 Non-C: 1.6 NR</td>
<td>Non-C: 46 of 89 patients with single implant</td>
<td></td>
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<tr>
<td>Kreissl et al. (2007)</td>
<td>Prospective</td>
<td>76</td>
<td>3i</td>
<td>Mean 5 years (0–80 months)</td>
<td>Non-C: 89</td>
<td>NR</td>
<td>NR</td>
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</table>

NR, not reported; Cant, cantilever FPDP; Non-C, non-cantilever FPDP; FPDP, fixed partial dental prosthesis.

The total number of prostheses included in the three studies was 216 (74 with and 142 without cantilever extensions), with the number of cantilever prostheses varying between 23 and 27 among the studies. The mean number of implants supporting the prostheses ranged between 1.7 and 2.7 for cantilever FPDPs and between 1.2 and 2.8 for non-cantilever FPDPs. In the study by Hägl et al. (2008), eight (30%) of the 27 included cases in the cantilever FPDP group had only one implant supporting the cantilever reconstruction. Two of the studies [Kreissl et al. 2007; Hägl et al. 2008] included a large proportion of single-implant restorations in the non-cantilever group, 52% and 81%, respectively.

Data on the mean length of implants and cantilever extensions were available in two studies [Wennström et al. 2004; Hägl et al. 2008]. The mean overall length of the implants varied between 10.1 and 12.7 mm, while the length of the cantilever extension was described as ‘crown units’ in one study (one unit in all but one FPDP) or as a mean length in millimeters in the other (9 mm). The two case–control studies also provided information regarding the type of antagonist dentition, which, in all cases but one (implant supported FPDP), was natural teeth or tooth-supported FPDPs.

Loss of prostheses and implants (Table 3)

Information regarding failure (loss) rates for prostheses with and without cantilevers could be retrieved from all three included studies. The loss of cantilever prostheses ranged between 4.3% and 11.1% [weighted mean 8.1%, 95% CI 4.2–12] compared with 3.7–4.5% [4.2%, 95% CI 3.7–4.7] for FPDPs without cantilevers. Hence, the calculated weighted mean 5-year survival rate was 91.9% [95% CI 88–95.8] for cantilever FPDPs and 95.8% [95% CI 95.3–96.3] for FPDPs without cantilevers. The reasons for loss of the prostheses in the cantilever groups in the two case–control studies [Wennström et al. 2004; Hägl et al. 2008] were reported to be fracture of an implant (three cases) and need for remaking the supra-construction [one case], while the two events in the non-cantilever groups were due to implant fracture. In the cohort study [Kreissl et al. 2007] biological complications were indicated as the reason for the loss of prostheses [one cantilever and four non-cantilever prostheses].

Implant loss during the 5-year function period was reported in all three studies. In each of the two case–control studies the implant loss was two (3.2%/4.3%) for the cantilever group and one (1.4%/3.1%) for the non-cantilever group, all due to fractures. The corresponding figures for the cantilever and non-cantilever FDP groups in the cohort study [Kreissl et al. 2007] were one (1.6%) and four (2.8%), respectively, and all were reported to have been lost as a consequence of biological complications. The weighted mean 5-year rate of implant loss was 2.9% [95% CI 1.4–4.5] for cantilever FPDPs compared with 2.4% [95% CI 1.4–3.5] for non-cantilever FPDPs.

Technical complications – supra-constructions

Technical complications related to the supra-constructions in the three included studies were reported to occur at a frequency of 13–26% [weighted mean 21.6%, 95% CI 11.9–31.2] for cantilever-FDPs compared with 0–12% [10.3%, 95% CI 2.1–18.5] for non-cantilever FDPs. The most common complications were minor porcelain fractures and bridge-screw loosening.
and three minor porcelain fractures], equally distributed between the cantilever and the non-cantilever FDP groups. Häg et al. (2008) also reported six events, but all occurring in the cantilever-FDP group (one superstructure fracture, four minor porcelain fracture, and one re-cementation). Of a total of 17 complications described in the cohort study by Kreissl et al. (2007), six belonged to the cantilever group, corresponding to an incidence rate of 26% as compared with 12% in the non-cantilever group.

**Event-free survival rate**
By taking all technical complications reported under consideration, the event-free survival rate over 5 years was calculated. For cantilever FPDPs the event-free survival rate was 66.7%–79.2% in the various studies [weighted mean 71.7%, 95% CI 64.2–79.1] and for non-cantilever it was FPDs 83.1%–96.3% [weighted mean 85.9%, 95% CI 77.7–94.1].

**Biological complications (Table 3)**
Bone-level changes were assessed only in the two case-control studies (Wenström et al. 2004; Häg et al. 2008). In both studies, the baseline radiograph was obtained at prosthesis installation and assessments of bone changes were performed at the FDP, implant and site levels. As for the standardization of the radiographic technique, one study (Wenström et al. 2004) reported the use of a custom-made stent to optimize the reproducibility of projection geometry, while the other study (Häg et al. 2008) used only a standardized parallel long-cone technique.

The mean bone loss at the FDP level in the cantilever and non-cantilever groups in the two studies amounted to 0.23–0.49 mm [weighted mean 0.35 mm, 95% CI 0.10–0.61] and 0.09–0.38 mm [weighted mean 0.23 mm, 95% CI 0.05 to 0.52], respectively. The magnitude of bone loss at the implant closest to the cantilever extension (implant level) was 0.23–0.39 mm [weighted mean 0.31 mm, 95% CI 0.15–0.46] compared with 0.05–0.23 mm [weighted mean 0.14 mm, 95% CI 0.04 to 0.32] at the end implant or a randomized selected implant in the control group.

Potential influence on peri-implant marginal bone loss of various confounding factors was analyzed in the two studies using multivariate regression analysis. Jaw of treatment [maxilla], and in one of the studies smoking habits [Wenström et al. 2004] were significant factors in the biological complications. The event-free survival rates were calculated using the Kaplan–Meier method and the log-rank test was used for evaluation of survival differences between the two groups.

The results of the survival analysis showed that the event-free survival rates were significantly lower in the cantilever group compared to the non-cantilever group (Häg et al. 2008). The mean survival time was 71.7% [95% CI 64.2–79.1] for the cantilever group and 85.9% [95% CI 77.7–94.1] for the non-cantilever group. This difference was statistically significant (log-rank test, p < 0.05).

**Table 3. Technical and biological complications – implant-supported FPDPs**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Lost prostheses n (%)</th>
<th>Lost implants n (%)</th>
<th>Complications superstructure n (%)</th>
<th>Biological complications – 5 years</th>
<th>Comments</th>
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<td><strong>Case–control studies</strong></td>
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<tr>
<td>Häg et al. (2008)</td>
<td>Cant: 3 (11.1%)</td>
<td>Cant: 2 (4.3%)</td>
<td>Cant: 6 (22%)</td>
<td>Cant: 0.23</td>
<td>The losses of prostheses were due to implant fractures (2 Cant and 1 Non-C) and need for remaking the superstructure (1 Cant). All lost implants were due to fracture. No significant difference in bone loss Cant vs. Non-C. 33% smokers in Cant, 11% in Non-C. Baseline: prosthesis installation. Peri-implantitis affected 4 implants (1 Cant vs. 3 Non-C).</td>
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<tr>
<td>Non-C: 1 (3.7%)</td>
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<td>Non-C: 1 (3.1%)</td>
<td>Non-C: 0 (0%)</td>
<td>Non-C: 0.09</td>
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<td>Non-C: 0.05</td>
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<td><strong>Cohort studies</strong></td>
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<td>Wenström et al. (2004)</td>
<td>Cant: 2 (8.3%)</td>
<td>Cant: 2 (3.2%)</td>
<td>Cant: 3 (13%)</td>
<td>Cant: 0.49</td>
<td>The losses of prostheses were due to implant fractures. All lost implants were due to fracture. No significant difference in bone loss Cant vs Non-C. 42% smokers in Cant, 19% in Non-C. Baseline: prosthesis installation. Peri-implantitis NR.</td>
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<tr>
<td>Non-C: 1 (3.8%)</td>
<td></td>
<td>Non-C: 1 (1.4%)</td>
<td>Non-C: 3 (12%)</td>
<td>Non-C: 0.38</td>
<td></td>
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<tr>
<td></td>
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<td></td>
<td></td>
<td>Cant: 0.39</td>
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<tr>
<td>Kreissl et al. (2007)</td>
<td>Cant: 1 (4.3%)</td>
<td>Cant: 1 (1.6%)</td>
<td>Cant: 6 (26%)</td>
<td>NR</td>
<td>All lost prostheses were due to implant loss. Reasons for loss of implants not reported. % smokers not reported. No radiographic analysis. Peri-implantitis NR.</td>
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<tr>
<td>Non-C: 4 (4.5%)</td>
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<td>Non-C: 4 (2.8%)</td>
<td>Non-C: 11 (12%)</td>
<td>NR</td>
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<td><strong>Weighted mean (95% CI)</strong></td>
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<tr>
<td>Cant: 8.1% (4.2–12)</td>
<td>Cant: 2.9% (1.4–4.5)</td>
<td>Cant: 20.3% (12.8–27.9)</td>
<td>Cant: 0.35 (0.1–0.6)</td>
<td>Cant: 0.31 (0.1–0.5)</td>
<td>Event free survival rate: Cant: 71.7% (64.2–79.1) Non-C: 85.9% (77.7–94.1)</td>
</tr>
<tr>
<td>Non-C: 4.2% (3.7–4.7)</td>
<td>Non-C: 2.4% (1.4–3.5)</td>
<td>Non-C: 9.7% (1.9–17.6)</td>
<td>Non-C: 0.23 (–0.1–0.6)</td>
<td>Non-C: 0.14 (0–0.3)</td>
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NR, not reported; Cant, cantilever FPDP; Non-C, non-cantilever FPDP; FPDP, fixed partial dental prostheses.
et al. 2004], was associated with a significantly increased magnitude of marginal bone loss. Type of FPDPs (with or without cantilever extension) had no significant effect on marginal bone loss.

Discussion

In the present systematic review, the incidence of loss and technical and biological complications of FDPs with cantilever extensions were described. To address the focus question ‘to what extent do cantilevers affect survival and complications of implant borne reconstructions in partially edentulous patients’, the approach in the search was to identify longitudinal studies, prospective or retrospective, with at least 5 years of follow-up and reporting prosthesis-based data. It is generally acknowledged that longitudinal studies with a time span of at least 5 years are required to properly evaluate the outcome of implant treatment [Wennström & Palmer 1999; Berglundh et al. 2002; Pjetursson et al. 2004a]. Although we accepted for inclusion studies that presented data for a cohort with a mean follow-up of 5 years, only three studies qualified for inclusion. In a previous systematic review on implant therapy [Berglundh et al. 2002], it was suggested to exclude studies in which <80% of the initial subject sample had been followed for 5 years. If this criterion had been applied, only one study [Wennström et al. 2004] would qualify for inclusion since in the other two studies [Kreissl et al. 2007; Härlg et al. 2008] only 46–65% of the implant constructions were observed for a period of 5 years. However, because of the scarcity of identified studies addressing the issue of cantilever extensions, we decided to retain these studies.

Based on the three studies included in the current review, the calculated overall 5-year prosthesis survival rate was 92% for cantilever FPDPs, compared with 96% for non-cantilever FPDPs. Although these figures may indicate a somewhat inferior performance for the cantilever prostheses, the results should be interpreted with caution because the sample size is small. The overall prosthesis survival rate in the included studies was comparable with the results of a previous systematic review on implant-supported FDPs [Pjetursson et al. 2004a], in which a meta-analysis including 14 studies yielded an overall estimated survival rate of 95% (95% CI 92.2–96.8) after 5 years.

The event-free survival rate, i.e. the proportion of reconstructions that remained in function after 5 years without any technical complications, was estimated to be 72% for FPDPs with cantilever extension and 86% for FPDPs without cantilevers. However, the comparison with the available literature is difficult as the way in which data are generated and presented lacks uniformity. In a previous systematic review on implant-supported FDPs [Pjetursson et al. 2004a], including three studies reporting on the incidence of patients without any complication, the estimated success rate after 5 years was 61.3% (95% CI 53.3–66.8). In another systematic review [Berglundh et al. 2002], the 5-year incidence of technical complications for implant-supported FDPs, calculated at the patient level, was reported to be 23%. Taken together, these data indicate that technical complications are common for implant-supported prostheses, both with and without cantilever extensions.

It has been suggested [Pjetursson et al. 2004a] that technical complications should be divided into major [implant fracture, loss of suprastructure], medium [abutment, veneer or framework fracture] and minor [abutment or screw loosening, loss of retention, loss of veneer hole sealing, veneer chipping fracture], and that the type and number of events should be reported separately. Implant fractures were in the two case–control studies reported to vary between 1.4% and 4.3% across the treatment groups. Comparable data reported in the systematic review by Pjetursson et al. [2004a, 2004b] on implant-supported FPDPs in general revealed a cumulative incidence of 0.4%. The fact that the four implants that fractured in the cantilever groups of the two case–control studies included in the current systematic review had a narrow diameter (3.3–3.5 mm) suggests that other factors in addition to the cantilever extension should be considered when evaluating the mechanical risks of a specific prosthetic design. The study by Härlg et al. (2007) had a skewed distribution in the proportion of narrow implants between the treatment groups: 39% and 7% for the cantilever and non-cantilever groups: respectively. In the other case-control study [Wennström et al. 2004], one of the two implant fractures in the cantilever group occurred in a patient who was diagnosed as a bruxer. Furthermore, in this study the mean height of the supraconstructions was significantly greater in the cantilever group than in the non-cantilever group, which could be regarded as yet another potential prosthetic-related factor that might contribute to the incidence of technical complications. Nevertheless, this study reported a low frequency of technical complications [0.12 incidence/patient] that were equally distributed among the groups and comparable with the calculated 5-year incidence/patient of 0.24 technical complications for FPDPs reported in a previous systematic review [Berglundh et al. 2002].

Another prosthesis-related factor that has been suggested to contribute to an increase in the rate of technical complications is the type of antagonists [Davis et al. 2003]. Further, it is well recognized that loading may be significantly higher in posterior segments as compared with anterior regions [Rangert et al. 1995] and that more prosthetic complications may occur in the posterior regions [Nedir et al. 2006]. In the current review, two studies reported information about implant position and type of antagonists. Eighty-five percent to 100% of the FPDPs were placed in the premolar–molar regions and all were functioning against natural teeth or FPDPs supported by teeth or implants.

The mean overall marginal bone-level change after 5 years at the implant-supported FPDPs reported by two studies included in this review was small and well below the degree of bone loss acceptable according to the success criteria described by Albrektsson et al. (1986). Cantilever extensions did not significantly influence the bone changes. On the other hand, factors such as jaw of treatment (maxilla) and smoking habits appeared to be significant for observed peri-implant marginal bone loss. The presence of cantilever extensions and its effect on crestal bone loss were also analyzed in a prospective study with partially dentate patients who were restored with FPDPs in the posterior region [Blanes et al. 2007]. Neither the presence of a mesial nor a distal cantilever had a significant effect on peri-implant bone
loss after an observation period of 6 years. The biological plausibility that excessive loading results in increased marginal bone loss is controversial. Implant failure as a result of excessive occlusal load in a lateral direction was demonstrated in experimental studies in a monkey model [Isidor 1996, 1997], suggesting that it is possible to induce loss of osseointegration when the forces are beyond the repair potential of the bone. However, under clinical conditions, the biological impact and categorization of excessive load remains unclear and its translation into peri-implant marginal bone loss has not been demonstrated. Although early observations made in clinical studies suggested an association between excessive loading and peri-implant bone loss [Quirynen et al. 1992], bivariate analyses should be interpreted with caution because of potential skewed distribution of confounding factors. Other factors such as smoking [Lindquist et al. 1997] and maxilla vs. mandible [Jemt & Lekholm, 1993] have also been associated with peri-implant bone loss. Both case-control studies included in this systematic review used multivariate models for analysis and found cantilever extension to be a factor without a significant effect on observed marginal bone loss when the confounding factors were controlled in the statistical model. Several other variables related to the FPDP configuration have been suggested to influence its loading capacity, such as the buccolingual occlusal extension of the prostheses in addition to the above-mentioned height of the supra-contruction and the number and inclination of the supporting implants [Rangert et al. 1997]. Also, implant designs and surface roughness influence the bone-implant support capacity. Hence, determining the potential effect of one loading-associated factor on peri-implant crestal bone loss is complicated unless other variables are adequately controlled in clinical trials.

Peri-implantitis is an important biological complication resulting in bone loss but was not considered as an outcome in the current review because of the lack of a plausible biological relationship with the presence/absence of cantilever extension. Information regarding the condition of the peri-implant tissues in clinical studies related to dental implants is scarce [Berglundh et al. 2002]. The incidence of peri-implantitis was reported in one study included in the current review [Hälg et al. 2008], 5.1% of the prostheses were affected. The cumulative incidence of peri-implantitis and soft tissue complications for FPDPs after 5 years was estimated to be 8.6% in a previous systematic review [Peterson et al. 2004a, 2004b]. A more recent systematic review [Zitzmann & Berglundh 2008] described alarmingly higher figures. They retrieved data from two study samples and peri-implantitis was found in these studies in 28% and ≥ 56% of the subjects.

In the current review, only three studies were included and only one study presented data with > 80% of the patients followed for 5 years. Of the excluded studies not fulfilling the criterion of a minimum mean follow-up of 5 years, high short-term survival rates (95.6–100%) were reported in three longitudinal studies with a mean follow-up time ranging between 3.9 and 4.5 years [Johansson & Ekdeldt 2003, Romeo et al. 2003, Becker 2004]. In another excluded study [Nedir et al. 2006], comparative data of the prosthetic complications associated with different implant prosthetic designs were presented. After a mean follow-up of 3.3 years [44% of the patients followed for 5 years], the complication rate for FPDPs [the majority placed in the posterior regions] was 29.4% for the cantilever and 7.9% for non-cantilever prostheses.

It is obvious from this systematic review that there is a need for additional prospective controlled clinical studies with at least 5 years of follow-up to properly determine to what extent cantilever extensions may affect the survival and complications of implant-borne reconstructions.

Conclusions

Within the limitations of the current review, the following conclusions can be made:

- The 5-year survival rate was high for both cantilever and non-cantilever FPDPs [91.9% vs. 95.8%].
- The most common reason for loss of FPDPs with cantilever extensions was implant fracture.
- The incorporation of cantilevers into implant-borne prostheses was associated with a higher incidence of technical complications related to the supra-constructions [20.3% vs. 9.7% for non-cantilever FPDPs]. Minor porcelain fractures and bridge-screw loosening were the most common technical complications.
- For cantilever FPDPs the 5-year event-free survival rate was 71.7% compared with 85.9% for non-cantilever FPDPs.
- The incorporation of cantilevers into implant-borne prostheses did not have any significant effect on the amount of peri-implant marginal bone loss, either at the prosthesis level or at the implant next to the cantilever.

Clinical implications

An implant-supported FPDP with a short cantilever extension (one tooth unit) is an acceptable restorative therapy, and might be considered as an alternative to procedures that require more advanced surgery [e.g. sinus graft, etc.] or for esthetic reasons.

References – meeting the inclusion criteria of the systematic review


References – not included in the systematic review, but quoted in the manuscript


