Implant and Prosthodontic Related Complications

Chapter 9

Systematic Review on Biological and Technical Complications with Fixed Implant Rehabilitations for Edentulous Patients

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Key words: biological complications, technical complications, implant fixed prostheses, fully edentulous
Abstract

Objective: The purpose of this systematic review was to assess the incidence and type of biological and technical complications associated with Implant Fixed Dental Prostheses (IFDPs) for edentulous patients.

Materials and Methods: An electronic MEDLINE/PubMED search was conducted to identify randomized controlled clinical trials and prospective cohort studies with IFDPs for edentulous patients. Reports on complications with at least 5-year follow-up after prosthesis insertion were selected. Pooled data was statistically analyzed and cumulative complication rates were calculated by meta-analysis and regression.

Results: From a total of 281 one-piece IFDPs (mean exposure time of 9.5 years) and 599 complication events, the complication rate was 22.5% estimated per 100 restoration years (95% CI: 20.7-24.3). Cumulative rate of “prosthesis free of complications” after 5- and 10-years was 32.4% (95% CI: 29.6-35.5) and 10.5% (95% CI: 8.8-12.6), respectively. Most common implant-related biological complication was peri-implant bone loss (>2mm), with a complication rate of 20.1% (95% CI: 17.7-22.6) after 5 years and 40.3% (95% CI: 36.9-43.7) after 10 years. Most frequent implant-related technical complication was screw fracture, yielding a 5-year complication rate of 10.4% (95% CI: 8.8-12.0) and a 10-year rate of 20.8% (95% CI: 18.5-23.1). Most frequent prosthesis-related biological complication was hypertrophy or hyperplasia of tissue around the IFDPs, with complication rate of 13.0% (95% CI: 10.6-15.4) and 26.0% (95% CI: 22.6-29.3) after 5 and 10 years, respectively. Most common prosthesis-related technical complication reported with IFDPs was the veneering material chipping/fracture with an estimated complication rate of 33.3% (95% CI: 31.1-35.5) at 5 years and 66.6% (95% CI: 63.5-69.7) at 10 years.

Conclusion: Biological and technical complications after the insertion of IFDPs occur consistently. These events may not lead to implant/prosthetic failures but are significant in relation to the numbers of repair and maintenance sessions.
Introduction

The longitudinal effectiveness of osseointegrated implants with more than 20 years of stable success has been demonstrated for both partially and completely edentulous patients.\textsuperscript{1,2} The main focus of the longitudinal studies was the success of osseointegration and the survival of the implants. It is now accepted that biologic and technical (mechanical) complications routinely occur with IFDPs.\textsuperscript{3,4} Additionally, it has been emphasized that longitudinal studies should report on complications and adverse clinical outcomes in order to provide clinicians with unbiased, thorough information for evidence-based treatment planning.\textsuperscript{5}

A previous systematic review specified two categories of complications that occur in implant dentistry: biological and technical.\textsuperscript{6} ‘Biological complications’ refer to disturbances in the implant function being characterized by biological processes affecting the supporting peri-implant tissues. Biological complications include early and late implant losses, adverse reactions in the peri-implant hard and soft tissues, and the detection of such complications requires adequate clinical and radiographic examination methods.

‘Technical complications’ pertain to a collective term for mechanical damage of the implant/implant components and suprastructures. A review on the clinical complications (biological and technical) of implant/prosthetic rehabilitations, concluded that variations in study design and reporting procedures limited the available data and therefore precluded proper analysis of certain complications.\textsuperscript{7}

Nowadays, an analysis on complications and success rates seems more relevant than just calculating survival rates. Prosthetic complications after the definitive prosthesis insertion may not lead to implant loss but can result in an increased number of repairs and maintenance sessions. Only few studies have attempted to assess quantitatively the costs associated with implant IFDPs and maintenance.\textsuperscript{8,9} From the socio-economical viewpoint, the patient preference for specific treatment options relies on the longitudinal efficacy of the option coupled with the associated cost and maintenance.\textsuperscript{10}
A systematic review highlighted that as much as 38.7% of all implant-supported fixed partial dentures (FPDs) for partially edentulous patients had some type of complication during an observation period of at least 5 years. Moreover, it is generally accepted that meaningful interpretation of the clinical outcomes of implant treatment requires a time span of at least 5 years. However, limited data related to the complications encountered with fixed implant rehabilitations for edentulous patients after an observation period of at least 5 years is available.

The purpose of this article is to systematically review prospective clinical studies reporting on complications associated with IFDP in edentulous patients.

**Materials and Methods**

**Search strategy**


The electronic search was supplemented by manual search of the bibliographies of all the full-text articles and related reviews that were selected from the initial search (Fig.1). Selected articles were collected in a reference manager software (Endnotes, Thomson Reuters, New York, NY) and duplicates were discarded electronically. The inclusion criteria are presented in Table 1.

Titles and abstracts were initially screened by two calibrated reviewers for potential inclusion. All titles and abstracts selected by the two reviewers were discussed individually for full-text
reading inclusion. The full-text reading of related publications was carried out independently by the two reviewers. Inter-reviewer agreement was always determined with the use of Cohen’s kappa K-statistics. In cases where information was not clear, the issue was elucidated by contacting the authors of the pertinent study via email.

The initial search yielded 4,563 hits after discarding duplicate references. The subsequent search at the title level exhibited 2,284 titles (k-score=0.65) and further at the abstract level identified 625 abstracts (k-score=0.7). The independent abstract investigation revealed 190 articles for full-text reading (k-score=0.8). From these 190 articles, 11 fulfilled the inclusion criteria and were suitable for statistical analysis.

**Excluded studies**

Out of the 190 studies selected for full-text reading, 179 were finally excluded. The main reasons were follow-up period of less than 5 years, as well as not detailed report on both technical and biological complications after definitive prosthesis insertion. In addition to that, multiple publications on the same cohort of patients were also excluded and the most longitudinal was to be included for statistical analysis. However, one longitudinal study with a range of 18-23 years of follow-up was excluded since a significant percentage of the cohort patients could not attend the final recall and/or had passed away. For this study, the previous report with 12-15 years of follow-up was further analyzed since it satisfied the inclusion criteria.

**Data extraction**

Data was collected at 5- and 10-year endpoints. Implant- and prosthesis-based biological and technical complications were identified and recorded. Patient cohort demographics were also collected and are shown in Table 2.

**Statistical analysis**

For each study, event rates for IFDPs and/or implants were calculated by dividing the total number of events by the total IFDPs or implant exposure time in years. For further analysis, the
estimates (complication event rates) were used to calculate the standard errors. Standard errors were estimated by the standardized formula of complication rates divided by the square root of the number of complication cases. With each of the study’s estimate and standard error obtained, we computed further in order to achieve at the 95 percent confidence intervals (95% CI) of the summary estimates of the event rates. All statistical analyses were performed using STATA (Stata Statistical Software, Version 11.0, StataCorp LP, College Station, TX, USA), and level of statistical significance (alpha level) was based at 0.05. Using the METAN command in the STATA computing environment, we assessed the heterogeneity of the study-specific event rates. The STATA software computed the goodness-of-fit statistics and the associated P-value was calculated. If the goodness-of-fit P-value was below 0.05, indicating heterogeneity, meta-analysis with random-effects was used to obtain a summary estimate of the event rates. Five-year and 10-year survival proportions were calculated via the relationship between event rate and survival function S, S(T)=exp(-T * event rate), by assuming constant event rates. The 95%CI for the survival proportions were calculated by using the 95% confidence limits of the event rates.16

Results

Included studies/Study characteristics

The electronic and manual search yielded 1 RCT and 10 prospective studies that satisfied the inclusion criteria and were analyzed statistically.15,17-26 These studies were conducted in academic institutions and three commercially available implant systems were used (AstraTech, Nobel Biocare, Straumann). The year of publication for these 11 studies ranged from 1996 to 2009. Eight studies were published after 2002, while 3 studies were reported between 1996 and 1998. In all studies, the prosthetic design featured one-piece, screw-retained, metal-resin prostheses. Only two articles reported on a small number of porcelain fused to metal IFDPs among the metal-resin prostheses.20,26 The 11 selected studies were divided into 2 groups: one group comprised of studies with at least 5 years of observation follow-up and the second group included studies with 10- to 20 years of follow-up (Table 3).
However, 4 studies were further excluded from the meta-analysis because they failed to report detailed information on prosthetic maintenance events. Specifically on veneering material chipping/fracture, which was the most common technical complication.\textsuperscript{23-26}

For each of the 7 finally selected studies, complication rates for IFDPs were calculated by dividing the total number of complication events by the total prosthesis exposure time in years. The summary of random-effects meta-analysis using complication rates, confidence intervals, and the weight of each study by exposure time is shown in Fig. 2. The mean prosthesis exposure time was 9.5 years. A descriptive analysis of the included studies and complications is shown (Table 3). The complication rate was 22.5% estimated per 100 restoration years (95% CI: 20.7-24.3). The cumulative rate of “prosthesis free of complications” after 5- and 10-years was 32.4% (95% CI: 29.6-35.5) and 10.5% (95% CI: 8.8-12.6), respectively.

\textbf{Biological complications}

Biological complications for the fixed complete arch implant rehabilitations encompassed the following: soft tissue dehiscence, peri-implant bone loss exceeding 2mm, peri-implant mucositis, inflammation under the fixed prosthesis and hypertrophy/hyperplasia of soft tissue. They were further categorized as implant- and prosthesis-related (Tables 4 \& 5).

The most frequent biological implant-related complication was excessive peri-implant crestal bone loss exceeding 2mm. Four studies reported on this specific complication.\textsuperscript{18,20-22} From a total number of 1392 supporting implants analyzed, this complication occurred in 54 implants. The estimated annual complication rate was 4% (95% CI: 3.0-5.1). The 5- and 10-year complication rate was 20.1% (95% CI: 17.7-22.6) and 40.3% (95% CI: 36.9-43.7), respectively.

The second most common implant-related biological complication was peri-implant mucositis. Two studies reported on this complication.\textsuperscript{20,21} From a total number of 534 supporting implants analyzed, this complication occurred in 10 implants, thus yielding an estimated annual complication rate of 2.1% (95% CI: 0.8-3.4). This resulted into 5- and 10-year estimated complication rates of 10.5% (95% CI: 7.6-13.4) and 21.1% (95% CI: 16.9-25.2), respectively.
The most frequent biological prosthesis-related complication was hypertrophy/hyperplasia of soft tissue, whereas the second most frequent was tissue inflammation under the IFDP. Two studies reported on each of these 2 complications.\textsuperscript{20,21} From a total number of 78 fixed dental prostheses analyzed, hypertrophy/hyperplasia of soft tissue occurred in 23 prostheses. The estimated annual complication rate was 2.6% (95% CI: 1.5-3.7). The 5- and 10-year complication rates was 13.0% (95% CI: 10.6-15.4) and 26.0% (95% CI: 22.6-29.3).

From a total number of 120 IFDPs analyzed, tissue inflammation under the IFDPs occurred in 11 prostheses.\textsuperscript{20,22} The estimated annual incidence rate was 1.1% (95% CI: 0.5-1.8). The 5- and 10-year complication rate was 5.6% (95% CI: 4.2-7.1) and 11.3% (95% CI: 9.2-13.4), respectively.

**Technical complications**

Technical/mechanical complications encountered were as follows: screw loosening/fracture, veneering material chipping/fracture, framework fracture, loss of screw access filling material, fracture of the opposing restoration, conversion of the fixed prosthesis to overdenture/CD, patient dissatisfaction and other complications. They were further categorized as implant-related and prosthesis-related.

The most frequent implant-related technical complication reported with the complete arch IFDPs was abutment/occlusal screw fracture. Three studies reported on incidences of screw fracture.\textsuperscript{15,17,20} From a total number of 752 supporting implants analyzed, screw loosening was reported to occur in 31 implants. The estimated annual complication rate was 2.1% (95% CI: 1.3-2.8). The 5- and 10-year estimated complication rate was 10.4% (95% CI: 8.8-12.0) and 20.8% (95% CI: 18.5-23.1), respectively.

Second most common implant-related technical complication was screw loosening; parafunction resulting in occlusal overload, cyclic stress loading fatigue form occlusal forces and framework misfit has been suggested as reasons of screw fracture. Six studies reported on screw loosening.\textsuperscript{15,18-22} For a total of 1713 implants, fracture events were encountered in 37 implants, resulting in annual incidence rate of 1.9% (95% CI: 1.3-2.4). This translated into 5- and 10-year estimated complication rate of 9.3% (95% CI: 7.9-10.6) and 18.5% (95% CI: 16.6-20.4).
The most frequent prosthesis-related technical complication reported with the complete arch fixed prostheses was veneering material chipping/fracture. All 7 studies reported on veneering material chipping/fracture.\textsuperscript{15,17-22} From a total number of 281 IFDPs analyzed, 177 events of veneer chipping/fracture were reported. This yielded an estimated annual complication rate of 6.7\% (95\% CI: 5.7-7.6). Meta-analysis revealed an estimated complication rate of 33.3\% (95\% CI: 31.1-35.5) at 5-years and 66.6\% (95\% CI: 63.5-69.7) at 10-years.

The second most common prosthesis-related mechanical complication was loss of screw access filling material. Two studies reported on this complication.\textsuperscript{15,17} A total of 58 events were recorded with 78 IFDPs, yielding an annual rate of 4.6\% (95\% CI: 3.4-5.8). The 5- and 10-year complication rate was 22.9\% (95\% CI: 20.2-25.5) and 45.8\% (95\% CI: 42.0-49.5).

Another prosthesis-related technical complication was the fracture of the opposing complete denture. Two studies reported on this complication.\textsuperscript{17,20} From a total number of 78 IFDPs analyzed, opposing denture fracture was reported to occur 15 times, translating into an estimated annual complication rate of 1.7\% (95\% CI: 0.8-2.6). The 5- and 10-year estimated complication rate was 8.5\% (95\% CI: 6.6-10.4) and 16.9\% (95\% CI: 14.2-19.7), respectively.

Three studies reported on framework fracture and this complication occurred in 16 out of 153 IFDPs.\textsuperscript{17,20,22} Framework fracture annual incidence rate was 1\% (95\% CI: 0.5-1.5), yielding a 5- and 10-year estimated complication rate of 4.9\% (95\% CI: 3.8-6.0) and 9.8\% (95\% CI: 8.3-11.3).

Out of 120 IFDPs 7 were converted into implant overdentures because of late implant losses. A total of two studies reported on this type of complication.\textsuperscript{17,22} The annual incidence rate was 0.5\% (95\% CI: 0.1-0.9), whereas 5- and 10-year rates were 2.6\% (95\% CI: 1.7-3.4) and 5.2\% (95\% CI: 3.9-6.4). In addition to that, out of 120 IFDPs 2 were converted into complete dentures yielding a 5-year rate of 0.7\% (95\% CI: 0.3-1.2) and 10-year rate of 1.5\% (95\% CI: 0.8-2.1).\textsuperscript{17,22}

Moreover, in two studies and out of 90 prostheses analyzed, 3 IFDPs lead to patient dissatisfaction and had to be remade, resulting into 5- and 10-year rate of 1.8\% (95\% CI: 0.9-2.7) and 3.6\% (95\% CI: 2.3-4.9), respectively.\textsuperscript{15,20}
The incidence of other unspecified technical complications was 34 events in a total of 120 analyzed IFDPs, yielding an annual estimated complication rate of 2.5% (95% CI: 1.7-3.3). The 5-year complication rate for the non specified incidences was 12.5% (95% CI: 10.6-14.4) and the 10-year rate was 25.0% (95% CI: 22.4-27.7).

Discussion

The objective of this systematic review was to describe the biological and technical complications encountered with complete arch IFDPs for edentulous patients. For the treatment of the edentulous patients, metal-resin IFDPs opposed by complete dentures have been predominantly used. The main focus on these reports with complete arch IFDPs was the survival of the osseointegrated implants. These reports stated that veneering material fracture/wear was not major complication and was easily fixable. Hence, data on veneering chipping was not often reported. That was the reason for excluding 4 additional studies from the final statistical analysis.

Survival criteria have been well described in the literature but success criteria have not been comprehensively established yet. In a previous systematic review, success was defined as a prosthesis that remained unaltered and free of all complications throughout the entire observation period. No intervention was required to be made to the prosthesis during the clinical function follow-up.

However, the advances in contemporary oral implantology coupled with the patients’ high esthetic expectations underscore the necessity for more factors to be included in the success criteria assessment of the implant prostheses, besides the implant survival. A previous clinical study proposed success criteria for IFDPs based on implant, peri-implant tissues, prosthodontic and subjective parameters. The authors reported a 95.5% survival rate versus an 86.7% success rate when the proposed success criteria were applied. IFDPs were deemed as successful when a total of 4 or less complications (mild or moderate severity) were encountered and could be addressed chair side in a single visit. Additionally, patient satisfaction with overall treatment
should be rated good or excellent in order for the treatment outcome to be considered successful.

There is a lack of homogeneity in the dental literature on how the complications are reported as well as the different types of complications. Technical complications are common in implant prosthodontics and may jeopardize the functional and esthetic outcomes with the IFDPs. The absence of well-defined criteria might lead to overlooking relevant clinical implications such as frequent complication associated with a specific study design. Clinical implications must be cautiously interpreted in implant prosthodontics due to variations in the reported complications. In this context, well defined criteria should be used for reporting and assessing biological and technical complications. Moreover, the etiology of many biological and technical complications are not yet fully understood, leading to select treatment options based on personal experience and observational studies due to scarce evidence-based information.

In the present systematic review, a mean prosthesis exposure time of 9.5 years was calculated. A total of 599 complication events were recorded, translating in an estimated complication rate of 22.5% estimated per 100 restoration years (95% CI: 15.7-27.0) and a cumulative rate of “prosthesis free of complications” after 5- and 10-years was 34.3% (95% CI: 25.9-45.6) and 11.8% (95% CI: 6.7-20.8), respectively.

The most common implant-related biological complication was the peri-implant bone loss exceeding 2mm during clinical follow-up of at least 5 years. Moreover, the most frequent implant-related technical complication was abutment screw fracture. Three studies reported on incidences of screw fracture. Forces of greater magnitude than the clamping force of the screw joint can eventually cause screw loosening and/or fracture. The new abutment screw designs have focused on increasing the screw-joint preload. Moreover, the replacement of gold screws with screws that feature improved surface coatings like titanium have reduced the incidence of screw loosening which eventually leads to screw fracture. On the other hand, the most frequent prosthesis-related biological complication was hypertrophy or hyperplasia of tissue around the IFDP.
The most common prosthesis-related technical complication was the veneering material chipping/fracture. All 7 studies included in the final analysis of this systematic review reported on this specific complication. \textsuperscript{15,17-22} Veneer fracture is attributed to material failures (accumulated fatigue, plastic deformation), prosthetic design issues (framework misfit, inadequate prosthetic space, excessive cantilevers), patient characteristics (parafunctional activity) and laboratory errors (casting errors, firing failures).\textsuperscript{7} The preponderance of literature reports on screw-retained, metal-acrylic resin prosthetic design.\textsuperscript{33} The high incidence of acrylic resin chipping/fractures in both fixed and implant prosthodontics indicate that the problem cannot be completely avoided.\textsuperscript{34}

The use of ceramic materials could represent a long-lasting alternative to acrylic. However, there is paucity of reports on porcelain fused to metal IFDPs for edentulous patients with observation periods of at least 5 years. The 10-year cumulative rate of “prosthesis free of complications” of 11.8\% (95\% CI: 6.7-20.8) presented in this study raises questions on the advantage of retrievability that screw-retained IFDPs present over cement-retained restorations. In this context, the use of provisional cementation of IFDPs with ceramic veneering has been proposed.\textsuperscript{35-37} More prospective controlled clinical trials with at least 5 years of follow-up are necessary to determine the type and incidence of complications encountered with complete arch porcelain fused to metal IFDPs. Additionally, it is emphasized that longitudinal studies should report on complications and adverse clinical outcomes in order to provide clinicians with unbiased, thorough information for evidence-based treatment planning.\textsuperscript{5}

**Conclusion**

Fracture of the prosthesis veneering material in the most common adverse event associated with IFDPs in edentulous patients. The 5- and 10-year estimated complication rates with IFDPs clearly demonstrate that biological and technical complications after the definitive prosthesis insertion occur frequently. These events may not result in implant loss but can lead to numerous repair and maintenance sessions. Edentulous patients treated with IFDPs should be
informed about the high incidence of complications following definitive prosthesis insertion and about the need to attend a customized maintenance protocol for the long-term stability of their IFDPs.

References


Table 1. Inclusion criteria

- The studies should be randomized-controlled clinical trials (RCTs) or prospective cohort studies.
- The studies had follow-up time of at least 5 years.
- The baseline was the definitive prosthesis insertion.
- The studies included at least 10 edentulous patients with at least 1 edentulous arch.
- The studies reported on complete-arch, fixed implant rehabilitations for edentulous patients.
- The studies reported clearly on both biological and technical complications encountered with the fixed rehabilitations at the specific cohort of patients.
- Only studies with screw-type implants were considered. Studies reporting on zygoma, pterygomaxillary and transitional implants were excluded.

Table 2. Characteristics of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Study type</th>
<th>Total number of patients</th>
<th>Follow up time (years)</th>
<th>Implant system</th>
<th>Type of prosthesis/material</th>
<th>Treated arch</th>
<th>Opposing arch</th>
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<tbody>
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<td>74</td>
<td>10</td>
<td>Branemark</td>
<td>metal-resin</td>
<td>Both</td>
<td>CD/FCD</td>
</tr>
<tr>
<td>Gallucci 2009</td>
<td>prospective</td>
<td>45</td>
<td>5</td>
<td>Straumann</td>
<td>metal-resin/metal ceramic</td>
<td>Mandible</td>
<td>CD</td>
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<tr>
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<td>prospective</td>
<td>10</td>
<td>5</td>
<td>Branemark</td>
<td>metal-resin</td>
<td>Mandible</td>
<td>CD/RPD/FCD/FPD</td>
</tr>
<tr>
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<td>RCT</td>
<td>23</td>
<td>5</td>
<td>Straumann</td>
<td>metal-resin</td>
<td>Maxilla</td>
<td>CD/RPD/FPD/natural</td>
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<tr>
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<td>prospective</td>
<td>31</td>
<td>18 ~ 23</td>
<td>Branemark</td>
<td>metal-resin</td>
<td>Both</td>
<td>CD/FCD</td>
</tr>
<tr>
<td>Jemt 2002</td>
<td>prospective</td>
<td>50</td>
<td>5</td>
<td>Branemark</td>
<td>metal-resin</td>
<td>Maxilla</td>
<td>FCD/natural/RPD</td>
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<td>prospective</td>
<td>45</td>
<td>12 ~ 15</td>
<td>Branemark</td>
<td>metal-resin</td>
<td>Mandible</td>
<td>CD</td>
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CD: complete denture

FCD: fixed complete denture

RPD: removal partial denture

FPD: fixed partial denture
## Table 3. Descriptive and complication analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Total number of patients</th>
<th>Total number of prostheses</th>
<th>Total number of implants</th>
<th>Total of exposure time (years)</th>
<th>The mean exposure time (years)</th>
<th>Total number of complications</th>
<th>Estimated complication rate (per 100 prostheses years)</th>
<th>Estimated “prosthesis free of complications” rate after 5 years in percent (%)</th>
<th>Estimated “prosthesis free of complications” rate after 10 years in percent (%)</th>
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<td><strong>5-year follow up</strong></td>
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<tr>
<td>Gallucci 2009</td>
<td>45</td>
<td>45</td>
<td>237</td>
<td>225</td>
<td>5</td>
<td>60</td>
<td>26.7 (20.0-33.4)</td>
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<td>50</td>
<td>5</td>
<td>7</td>
<td>14.0 (3.6-24.3)</td>
<td>49.7 (29.6-83.4)</td>
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<td>50</td>
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<td>250</td>
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<td>36</td>
<td>14.4 (9.7-19.1)</td>
<td>48.7 (38.5-61.6)</td>
<td>23.7 (14.8-37.9)</td>
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<td><strong>10-year follow up</strong></td>
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<tr>
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<td>75</td>
<td>719</td>
<td>750</td>
<td>10</td>
<td>224</td>
<td>29.9 (25.6-33.8)</td>
<td>22.4 (18.5-27.3)</td>
<td>5.0 (3.4-7.5)</td>
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<td>31</td>
<td>33</td>
<td>244</td>
<td>660</td>
<td>20</td>
<td>155</td>
<td>23.4 (19.8-27.2)</td>
<td>30.9 (25.7-37.1)</td>
<td>9.6 (6.6-13.8)</td>
</tr>
<tr>
<td>Lindquist 1996</td>
<td>45</td>
<td>45</td>
<td>271</td>
<td>607.5</td>
<td>13.5</td>
<td>86</td>
<td>14.2 (11.2-17.1)</td>
<td>49.3 (42.4-57.2)</td>
<td>24.3 (18.0-32.7)</td>
</tr>
<tr>
<td><strong>Total Summary</strong></td>
<td>278</td>
<td>281</td>
<td>1957</td>
<td>2657.5</td>
<td>9.5</td>
<td>599</td>
<td>22.5 (20.7-24.3)</td>
<td>32.4 (29.6-35.5)</td>
<td>10.5 (8.8-12.6)</td>
</tr>
</tbody>
</table>

* Based on pooled effect size (ES) estimate of the random-effects meta-analysis weighted by exposure time
## Table 4. Summary of implant-related complications

<table>
<thead>
<tr>
<th>Complication type</th>
<th>Total number of implants</th>
<th>Total number of events</th>
<th>Total exposure time</th>
<th>Estimate event rates (95% CI)</th>
<th>Cumulative 5-year estimated complication rates (95% CI)</th>
<th>Cumulative 10-year estimated complication rates (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bone loss around an implant (&gt;2mm)</td>
<td>1392</td>
<td>54</td>
<td>1340</td>
<td>4.0 (3.0-5.1)</td>
<td>20.1 (17.7-22.6)</td>
<td>40.3 (36.9-43.7)</td>
</tr>
<tr>
<td>Peri-implant mucositis</td>
<td>534</td>
<td>10</td>
<td>475</td>
<td>2.1 (0.8-3.4)</td>
<td>10.5 (7.6-13.4)</td>
<td>21.1 (16.9-25.2)</td>
</tr>
<tr>
<td><strong>Technical Complications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screw fracture</td>
<td>752</td>
<td>31</td>
<td>1492.5</td>
<td>2.1 (1.3-2.8)</td>
<td>10.4 (8.8-12.0)</td>
<td>20.8 (18.5-23.1)</td>
</tr>
<tr>
<td>Screw loosening</td>
<td>1713</td>
<td>37</td>
<td>1997.5</td>
<td>1.9 (1.3-2.4)</td>
<td>9.3 (7.9-10.6)</td>
<td>18.5 (16.6-20.4)</td>
</tr>
</tbody>
</table>
### Table 5. Summary of prosthesis-related complications

<table>
<thead>
<tr>
<th>Complication type</th>
<th>Total number of prostheses</th>
<th>Total number of events</th>
<th>Total exposure time</th>
<th>Estimate event rates (95% CI)</th>
<th>Cumulative 5-year estimated complication rates (95% CI)</th>
<th>Cumulative 10-year estimated complication rates (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biological</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertrophy or hyperplasia of tissue</td>
<td>78</td>
<td>23</td>
<td>885</td>
<td>2.6 (1.5-3.7)</td>
<td>13.0 (10.6-15.4)</td>
<td>26.0 (22.6-29.3)</td>
</tr>
<tr>
<td>Inflammation under prosthesis</td>
<td>120</td>
<td>11</td>
<td>975</td>
<td>1.1 (0.5-1.8)</td>
<td>5.6 (4.2-7.1)</td>
<td>11.3 (9.2-13.4)</td>
</tr>
<tr>
<td><strong>Technical Complications</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veneering material chipping/fracture</td>
<td>281</td>
<td>177</td>
<td>2657.5</td>
<td>6.7 (5.7-7.6)</td>
<td>33.3 (31.1-35.5)</td>
<td>66.6 (63.5-69.7)</td>
</tr>
<tr>
<td>Loss of access hole filling</td>
<td>78</td>
<td>58</td>
<td>1267.5</td>
<td>4.6 (3.4-5.8)</td>
<td>22.9 (20.2-25.5)</td>
<td>45.8 (42.0-49.5)</td>
</tr>
<tr>
<td>Fracture of opposite denture</td>
<td>78</td>
<td>15</td>
<td>885</td>
<td>1.7 (0.8-2.6)</td>
<td>8.5 (6.6-10.4)</td>
<td>16.9 (14.2-19.7)</td>
</tr>
<tr>
<td>Framework fracture</td>
<td>153</td>
<td>16</td>
<td>1635</td>
<td>1.0 (0.5-1.5)</td>
<td>4.9 (3.8-6.0)</td>
<td>9.8 (8.3-11.3)</td>
</tr>
<tr>
<td>Conversion to overdenture</td>
<td>120</td>
<td>7</td>
<td>1357.5</td>
<td>0.5 (0.1-0.9)</td>
<td>2.6 (1.7-3.4)</td>
<td>5.2 (3.9-6.4)</td>
</tr>
<tr>
<td>Patients unsatisfied</td>
<td>90</td>
<td>3</td>
<td>832.5</td>
<td>0.4 (0-0.8)</td>
<td>1.8 (0-2.7)</td>
<td>3.6 (2.3-4.9)</td>
</tr>
<tr>
<td>Conversion to CD</td>
<td>120</td>
<td>2</td>
<td>1357.5</td>
<td>0.1 (0-0.4)</td>
<td>0.7 (0.3-1.2)</td>
<td>1.5 (0.8-2.1)</td>
</tr>
<tr>
<td>Other</td>
<td>120</td>
<td>34</td>
<td>1357.5</td>
<td>2.5 (1.7-3.3)</td>
<td>12.5 (10.6-14.4)</td>
<td>25.0 (22.4-27.7)</td>
</tr>
</tbody>
</table>
Figures
Figure 1. Search design and strategy

Electronic Search by keyword: 4563

Title selected agreed by both reviewers: 2284
↓ K=0.65

Abstract selected agreed by both reviewers: 625
↓ K=0.7

Full-text articles selected agreed by both reviewers: 190
↓ K=0.8

11 Articles Selected
Figure 2. Summary of random-effects meta-analysis using complication rates, confidence intervals, and the weight of each study by exposure time.