Clinical Outcomes of Implant-Supported Dental Prostheses: A Retrospective Analysis Considering Patient-Related Factors

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Purpose: To investigate the clinical performance of implant-supported dental prostheses (ISDPs), this retrospective clinical study observed influencing factors on survival of the prostheses and necessary maintenance treatments during the observation time and complications of the dental implants. Materials and Methods: Patients who were provided either with fixed implant-supported dental prostheses (FISDPs) or telescopic-retained removable implant-supported dental prostheses (TR-RISDPs) were included in this retrospective clinical study. Potential influencing factors on the survival probability of the prostheses were observed using Kaplan-Meier analysis: patient sex, type of prosthesis, location, dentition in opposing arch, participation in follow-up visits, and whether the patient had a previous history of oral cancer. The type and number of maintenance treatments and complications of dental prostheses were also analyzed. Results: A collective of 473 patients who were provided with either FISDPs (n = 320) or TR-RISDPs (n = 153) and 1,499 implants were included in the study. 6.6% of the prostheses (24 FISDPs and 7 TR-RISDPs) had to be replaced, and 6.3% of the implants (n = 45) were lost. The calculated 5-year survival probabilities were 87.4% for FISDPs and 95.5% for TR-RISDPs. FISDPs in patients who also had ISDPs in the opposing arch showed the lowest survival probabilities (P < .05). TR-RISDPs in patients who regularly attended follow-up visits showed the highest survival rates (P < .05). Maintenance treatments had to be performed at an earlier stage for patients with TR-RISDPs, and especially for TR-RISDPs located in the mandible (P < .05). Conclusion: FISDPs and TR-RISDPs showed good survival rates in this study. However, when planning FISDPs, the dentition in the opposing arch should be considered to prevent possible failure. TR-RISDPs indicate a higher need for aftercare measures, especially in the early years of function. Regular attendance of follow-up visits is still a decisive factor for success. Int J Oral Maxillofac Implants 2021;36:985–991. doi: 10.11607/jomi.8784

Keywords: dental implant, dental prosthesis, implant-supported, Kaplan-Meier estimate, retrospective studies

It is a standard method of treatment to provide edentulous or partially edentulous patients with implant-supported dental prostheses (ISDPs). Their promising survival times are documented in numerous studies.¹–²⁵ The treatment with ISDPs shows clear improvements for patients regarding mastication, speech function, esthetics, and quality of life, with a slightly higher amount of aftercare measures to be expected.²⁶–³² However, patients often face the question if a treatment with ISDPs represents the right treatment option for them. Many different factors such as age, oral comfort, esthetic demands, hygienic ability, acceptance for removable prostheses, bone supply and structure, willingness to have surgical procedures, and costs must be considered. Retrospective clinical studies can often be helpful to give the patient an overview of the clinical performance of the prostheses and potential problems, which are to be expected. Therefore, it is very important to perform outcome research regularly and to observe the clinical performance of widely used treatment methods like ISDPs to show their advantages but also their disadvantages for the patients.¹³–¹⁴,¹⁸–²⁵,³³

As retrospective clinical studies on ISDPs are still rare in the current literature, especially the direct comparison of fixed implant-supported dental prostheses and removable implant-supported prostheses, this study should contribute to the current research state.

Thus, it was the aim of the present study to evaluate possible differences in survival of fixed implant-supported dental prostheses (FISDPs) and telescopic-retained removable implant-supported dental prostheses (TR-RISDPs) and to evaluate possible differences regarding clinical performance as well as needed maintenance. The following null hypothesis was tested: The (1) survival rate and (2) need for maintenance will not differ for FISDPs or TR-RISDPs.
MATERIALS AND METHODS

In the course of this retrospective clinical study, the existing clinical data of patients who received ISDPs at the Department of Prosthodontics, Justus-Liebig-University Giessen, Germany, were analyzed. The data used were extracted from computer-based electronic health records, in which all treatment steps were recorded transparently at the exact date for each treatment appointment starting in the year 2004. The approval of the ethics committee of the medical faculty of the Justus-Liebig-University Giessen for processing the data has been obtained (Reg. No.164/11).

The inclusion criteria for this study were patients who were provided with either FISDPs or TR-RISDPs. Only patients with complete data sets (complete data regarding the treatment with ISDPs) and patients who showed up at least once at the department after placement (scheduled treatment appointments and ongoing yearly follow-up visits) of the ISDP were included in the study. Whenever patients received more than one ISDP, only one prosthesis was chosen at random and included in the study to avoid bias from clustering of events. Tooth-implant–supported prostheses were not included.

All dental implants were placed in a two-stage surgery at the Department of Oral and Maxillofacial Surgery, Justus-Liebig-University Giessen, Germany. Qualified dentists at the department solely performed treatment in accordance with a standardized treatment protocol. All ISDPs were manufactured uniformly in one dental laboratory according to the present study specifications. Before treatment started, all patients went through an oral hygiene program. After insertion of the ISDPs, all patients were asked to attend an annual follow-up program. During this yearly routine checkup, the restorations were inspected following standardized protocols. If patients showed up with minor or major problems (eg, pressure spots, loose screw connections or prosthesis, fractured veneers or acrylic material, or problems with implants), they were treated directly, and the treatment was documented in the computer-based electronic health records at the exact date. The ISDPs were indicated as in need of renewal when they could not be repaired after major damage or remodelled after implant loss.

For statistical analysis, a Kaplan-Meier estimate with 95% confidence intervals (CIs) was used. Survival of the ISDPs was set as the time between delivery of the prosthesis and the time the prosthesis had to be renewed (target event). Maintenance was set as initial adjustment directly following ISDP delivery, and therefore, the time of the first necessary maintenance procedure was set as the target event. If none of the aforementioned target events occurred, the case was censored, and the patient’s last documented visit at the department was considered the target event. To analyze the impact of the covariates on the survival rate and to estimate the hazard ratio (HR) for the chance of ISDPs ceasing function, a Cox regression was performed as well. The following factors were analyzed as covariates of the survival function (log-rank test, P < .05): patient sex, type of ISDP (either FISDP or TR-RISDP), location of the prosthesis (maxilla or mandible), dentition in opposing arch, attendance in follow-up program, and if the patient suffered from oral cancer before treatment or not.

RESULTS

Based on 555 previously identified patients, 38 patients with incomplete data sets, 32 patients who never showed up after ISDP placement, and 12 patients who received bar- or ball-retained RISDPs were excluded from the study. Therefore, 473 patients (230 women and 243 men; mean age: 52.1 years) with 473 restorations (320 FISDPs, 153 TR-RISDPs) and a total of 1,499 implants were included in the analysis (Table 1).

The group of FISDPs (n = 320) consisted of 295 (92.2%) single crowns (157 in the maxilla and 138 in the mandible) and 25 (7.8%) partial dentures (9 in the maxilla and 16 in the mandible), supported by a total of 745 implants. Before the treatment with FISDPs started, 66.3% of those patients showed a Kennedy Class III occlusion and 33.7% a Kennedy Class I or II occlusion.

Overall, 153 patients who were treated solely with TR-RISDPs (40 in the maxilla and 113 in the mandible), supported by 754 implants, were included in the analysis. 90.2% of these patients were fully edentulous, and 9.8% were partially edentulous with less than three remaining teeth. Most frequently, the TR-RISDPs were attached on four implants (62%), six implants (20.9%), eight implants (11.8%), and two implants (7.8%), whereby the most common treatment was with four implants in the mandible and eight implants in the maxilla.

The opposing dentition of all ISDPs is displayed in Table 2.

All patients provided with ISDPs were asked to undergo an annual follow-up program. Overall, 221 (46.1%) patients (141 FISDPs and 80 RISDPs) participated regularly in the program.

Altogether, 105 (22.2%) patients suffered from oral cancer prior to treatment. Of these patients, 54 (51.4%) needed bone remodeling before treatment (24 FISDPs and 31 TR-RISDPs).

The mean observation time of all ISDPs observed was 3.14 ± 2.99 years (2.94 ± 2.89 years for FISDPs and 3.54 ± 3.16 years for TR-RISDPs; maximum of 12.77 years). During the observation period, 6.6% (n = 31) of the ISDPs (24 FISDPs and 7 TR-RISDPs) ceased...
functioning, and 6.3% of the implants (n = 45) were lost. Fifteen ISDPs were lost in the maxilla (12 FISDPs and 3 TR-RISDPs), and 16 were lost in the mandible. The reasons for renewal are shown in Table 3.

### Survival of ISDPs

After 5 years, 87.4% of the FISDPs and 95.5% of the TR-RISDPs remained in function. The mean ± standard deviation (SD) expected survival time for the FISDPs was 9.8 ± 0.3 years (95% CI: 9.1 to 10.4 years), and for TR-RISDPs, it was 11.6 ± 0.4 years (95% CI: 10.7 to 12.4 years; not significant, P > .05; Fig 1). Thus, part (1) of the null hypothesis could not be rejected.

Patients who received FISDPs and also had ISDPs in the opposing arch showed a significantly (P = .05) shorter survival probability with an average expected survival time of 7.4 ± 0.7 years (95% CI: 5.9 to 9.0 years), in contrast to patients with a natural dentition (10.0 ± 0.4 years, 95% CI: 9.0 to 10.9 years) or conventional fixed partial prosthesis (10.1 ± 0.3 years, 95% CI: 9.3 to 10.8 years) in the opposing arch. The cumulative 5-year survival rates were 96.1% for patients with natural dentition in the opposing arch, 86.6% for patients with conventional fixed partial prostheses, and 75.2% for patients with ISDPs in the opposing arch (Fig 2). Also, Cox regression showed that patients who also had ISDPs in the opposing arch had a significantly higher risk for renewal of the FISDPs in comparison to the other patients (HR: 6.5).

Patients provided with TR-RISDPs who regularly attended the follow-up program showed a significantly higher survival probability (P < .05) with an average expected survival time of 12.0 ± 0.3 years (95% CI: 11.2 to 12.8 years) than patients who did not attend (7.9 ± 0.6 years, 95% CI: 6.5 to 9.2 years; Fig 3). In this regard, Cox regression also showed a significantly higher

### Tables

<table>
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<th>Table 1</th>
<th>Sex, Average Age, and Localization of the FISDPs and TR-RISDPs</th>
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<tbody>
<tr>
<td></td>
<td>Sex</td>
</tr>
<tr>
<td></td>
<td>Female</td>
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<tr>
<td>FISDP (n = 320)</td>
<td>155</td>
</tr>
<tr>
<td>TR-RISDP (n = 153)</td>
<td>75</td>
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<td>Total (n = 473)</td>
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<tr>
<th>Table 2</th>
<th>Opposing Dentition Versus Type of Dental Prosthesis</th>
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<tr>
<td></td>
<td>Natural teeth</td>
</tr>
<tr>
<td>FISDP (n = 320)</td>
<td>89</td>
</tr>
<tr>
<td>TR-RISDP (n = 153)</td>
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<tr>
<td>Total (n = 473)</td>
<td>89</td>
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<th>Table 3</th>
<th>Reasons for Renewal</th>
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<tr>
<td>Reason for Renewal</td>
<td>FISDP</td>
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<tr>
<td>Fracture of veneer</td>
<td>7</td>
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<tr>
<td>Loss of friction</td>
<td>–</td>
</tr>
<tr>
<td>Compromised esthetics</td>
<td>4</td>
</tr>
<tr>
<td>Loss of prosthesis</td>
<td>3</td>
</tr>
<tr>
<td>Fracture of abutment</td>
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<tr>
<td>Fracture of implant</td>
<td>3</td>
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<tr>
<td>Loss of implant</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
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</tbody>
</table>

**Fig 1** Outcome probability of all ISDPs dependent on the type of dental prosthesis (target event: renewal, n = 473; Kaplan-Meier).

**Fig 2** Outcome probability of all FISDPs dependent on the opposing dentition (target event: renewal, n = 320; Kaplan-Meier).
risk for renewal of the RISDPs for patients who did not regularly attend the follow-up program in comparison to patients who attended regularly (HR: 3.3).

The variables patient sex, location of the prosthesis, and the presence of an oral cancer disease did not influence the survival probability of the ISDPs significantly (P > .05).

### Maintenance Procedures

During the observational period, 53.1% (n = 251; 138 FISDPs and 113 TR-RISDPs) of all patients needed a total of 661 (263 FISDPs and 398 TR-RISDPs) maintenance treatments (Table 4).

Patients with TR-RISDPs got the first maintenance treatment significantly (P < .001) earlier than patients with FISDPs. The average time until the first maintenance became necessary was 4.3 ± 0.2 years (95% CI: 3.7 to 4.9 years) for FISDPs and 2.1 ± 0.2 years (95% CI: 1.5 to 2.6 years) for TR-RISDPs (Fig 4). Therefore, part (2) of the null hypothesis had to be rejected.

Patients with TR-RISDPs in the mandible, however, required maintenance treatments significantly earlier than patients with TR-RISDPs in the maxilla (P < .05; Fig 5). Neither sex, nor opposing dentition, nor attendance in the follow-up program, nor presence of an oral cancer disease had any effect on the average time until the first maintenance treatment was required (P > .05).

### Complications of Implants

During the observational period, 3.0% (n = 45) of all implants were lost. Eight implants fractured, 33 implants had to be removed following significant bone loss due to peri-implantitis, and 4 implants were lost following a tumor recurrence.

Type, distribution, and loss of implants are shown in Table 5. In eight patients of the TR-RISDP group, the prostheses were remodeled and remained in function on the remaining implants, whereas three TR-RISDPs were renewed following implant loss.

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**Table 4 Type and Percentage of Maintenance Procedures**

<table>
<thead>
<tr>
<th>Maintenance procedure</th>
<th>FISDPs</th>
<th>TR-RISDPs</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elimination of pressure spot</td>
<td>–</td>
<td>130 (32.7%)</td>
<td>130 (19.7%)</td>
</tr>
<tr>
<td>Retightening a connecting screw</td>
<td>48 (18.3%)</td>
<td>20 (5.0%)</td>
<td>68 (10.3%)</td>
</tr>
<tr>
<td>Reline</td>
<td>–</td>
<td>54 (13.6%)</td>
<td>54 (8.2%)</td>
</tr>
<tr>
<td>Improvement of friction</td>
<td>–</td>
<td>54 (13.6%)</td>
<td>54 (8.2%)</td>
</tr>
<tr>
<td>Repair of acrylic resin</td>
<td>–</td>
<td>50 (12.5%)</td>
<td>50 (7.5%)</td>
</tr>
<tr>
<td>Repair of veneer fracture</td>
<td>35 (13.3%)</td>
<td>21 (5.3%)</td>
<td>56 (8.5%)</td>
</tr>
<tr>
<td>Reattachment of prosthesis</td>
<td>118 (44.9%)</td>
<td>2 (0.5%)</td>
<td>120 (18.1%)</td>
</tr>
<tr>
<td>Renewal of occlusal seal</td>
<td>39 (14.8%)</td>
<td>14 (3.5%)</td>
<td>53 (8.0%)</td>
</tr>
<tr>
<td>Others</td>
<td>23 (8.7%)</td>
<td>53 (13.3%)</td>
<td>76 (11.5%)</td>
</tr>
<tr>
<td>Total</td>
<td>263 (100%)</td>
<td>398 (100%)</td>
<td>661 (100%)</td>
</tr>
</tbody>
</table>
In 12 patients of the FISDPs group (Kennedy Class II occlusion), the distal implants of the removable dental prostheses were lost. In eight cases, the FISDP was changed into a single crown, and in four patients, a new implant was placed and the patient was provided with FISDPs again. Eight patients of the FISDPs group (Kennedy Class III occlusion), who lost implants with single crowns, received new implants, and were provided with FISDPs again.

**DISCUSSION**

Using a retrospective longitudinal study design, this study aimed to evaluate the survival probability and maintenance needs of FISDPs and TR-RISDPs. Despite the differences in statistical methods in comparison to other studies, the entire setting is comparable to many other publications. Some other studies calculated survival by forming quotients (input-output-statistic) only or included more than one restoration per patient in the analysis, whereby better survival times in comparison to the present study result. Potential biases were eliminated as much as possible, as the treatment itself was carried out by qualified dentists following a standard treatment protocol and as all dentures were fabricated in the same calibrated dental laboratory. Furthermore, only one ISDP per patient was included in the study.

The biggest disadvantage of the present study can be seen in the missing follow-up data of the implants. This is because the implants were placed at a different department, and therefore, the necessary follow-up data were not available for the authors. Another major drawback of the study can be seen in the low participation rate (46%) of the patients in the yearly follow-up program. This is because most patients showed up immediately at the department when problems occurred and then refused to attend another check-up appointment. Furthermore, the differing group sizes (FISDPs = 320 and TR-RISDPs = 153) and the low number of target event “renewals” (n = 31) present methodical difficulties for the present study. Of positive note is the exact monitoring of the data of all relevant events (eg, maintenance procedures, complications, follow-up program) by using a standardized computer program for documentation.

The reasons for prosthesis replacement in the present study are in complete conformity with the literature. The 5-year survival rates of 87.4% and 69.9% for FISDPs calculated in this study are slightly lower compared with several other studies, which stated survival rates between 88.9% and 95.8% after 5 years. This may be related to the fact that the present study included a high number of patients (n = 320) in comparison to other studies. Moreover, most studies observed crowns and fixed dental prostheses separately. In addition, the fact that all kinds of materials (full-metal, metal-resin, and full-ceramic FISDPs) were included in the present study can be seen as a reason for the marginally lower survival rates. Several studies showed lower survival rates for full-ceramic restorations. Jung et al observed a higher amount of complications and lower survival rates for full-ceramic restorations in comparison to metal-resin crowns. In the present study, 30.9% of all observed FISDPs are full-ceramic restorations.

In contrast to that, the 5-year survival rates of 95.5% calculated for TR-RISDPs are slightly below the current literature, where survival rates of 95.1% to 100% are stated. A reason for this could be seen in the large collective of patients (n = 153) in this study. Kiener et al showed comparable survival rates for RISDPs in the maxilla.
It should be noted, though, that patients with oral cancer were also included in this study, whereby a lower survival rate of the implants can result.

The lower survival rates for FISDPs in patients with ISDPs in the opposing dentition has not been observed in other studies. Davis et al showed a higher amount of necessary maintenance requirements (e.g., fracture of the framework) for FISDPs opposed by fixed prostheses of similar design in comparison to natural teeth or complete dentures. In this study, seven FISDPs, with five of the patients showing ISDPs in the opposing dentition, had to be replaced following irreparable veneer fractures. Some studies showed a higher risk for veneer fractures with ISDPs in the opposing dentition. This might be because implants, in comparison to natural teeth, show a reduced sense of touch, which results in a poor assessment of the chewing force.38

Despite the fact that only 46.7% of all patients (141 FISDPs and 80 TR-RISDPs) regularly attended the follow-up program, only patients with TR-RISDPs showed higher survival rates. The reason for this result could be because patients with TR-RISDPs experience technical complications more often, so regular attendance in the follow-up program seems to be more important for them.7,20 Furthermore, nearly all patients in the TR-RISDPs group who attended the follow-up program showed an oral cancer history (78.2%). This could be explained by the fact that these patients are more aware of their oral health status due to their previous illness. In contrast, most patients with FISDPs visited the department only if problems occurred. Nevertheless, a regular yearly check-up, especially for patients with ISDPs, is strongly advisable.

Patients with TR-RISDPs and an oral cancer history showed a 2.8-year lower average survival rate in comparison to patients without oral cancer; however, this result was not significant (P > .05). Nevertheless, this result is in good accordance with other studies, which see the reasons for this in a higher implant loss due to vascular disorders of the bone and soft tissue and a dry mouth following radiation therapy. Except from the slightly lower survival rates of dental implants for these patients, it is often one of a few options to provide them with dental prostheses.

As already stated in previous studies, TR-RISDPs show a greater and earlier need for maintenance in comparison to FISDPs, not least because the connecting system between TR-RISDPs and implants consists of several components, which are more susceptible to errors in handling and wear.

In patients with TR-RISDPs in the mandible, a significantly shorter period of time until the first maintenance intervention was observed. However, Andreiotelli et al and Kiener et al showed opposite results and described a higher amount of necessary maintenance treatments for RISDPs located in the maxilla in their studies. The results of the present study could be explained by the fact that 73.9% of the observed TR-RISDPs were located in the mandible, which signifies an increased focus on the mandible. Furthermore, due to advanced bone resorption, especially of the mandible, patients more often complain about pressure spots and ask for adjustment of the TR-RISDPs. Thus, in the present study, 89.2% of all pressure spot eliminations were carried out in the mandible.

The reasons for implant loss and the overall loss rate of 3.0% are comparable with other studies. In the group of patients with FISDPs, 2.6% of the implants were lost, which is in good accordance with the studies of Aglietta et al and Visser et al, who cited loss rates between 2.3% and 3.3%. The TR-RISDPs group showed a slightly higher amount of implant losses (3.4%) in comparison to the FISDPs group (2.6%) in this study. This result was also confirmed in the study by Berglundh et al. However, some studies reported no loss of dental implants, which could be explained by shorter periods of observation (> 5 years) and a lower amount of observed implants in comparison to the present study.

CONCLUSIONS

Within the limitations of this retrospective study, it can be concluded that FISDPs and TR-RISDPs show good survival rates after 5 years in function. When planning a treatment with ISDPs, especially with FISDPs, the dentition in the opposing arch should be considered to prevent possible failures. Patients and dentists have to be alert of a higher amount of necessary aftercare measures, especially for TR-RISDPs located in the mandible. Neither the presence of a previous oral cancer disease nor patient sex or location of the ISDPs influenced the survival rates of the ISDPs significantly in this study. Regular attendance in follow-up visits is still a decisive factor for success and highly recommended to prevent serious failings.

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