Purpose: Treatment by means of implant-supported immediately loaded fixed full-arch prostheses is known to be related to biologic and technical complications. The aim of this retrospective study was to investigate the prevalence and moment of occurrence of biologic and technical complications happening in immediately loaded fixed full-arch prostheses. Materials and Methods: This study investigated patients who received treatment with immediately loaded fixed full-arch prostheses using four to six implants from 2007 to 2013. The investigation included biologic and technical complications. Complications were depicted regarding their prevalence and their first time of occurrence. Statistical analysis was performed regarding the differences of the mean complication values between the mandible and the maxilla and between technical and biologic complications. Results: The investigation included 482 immediately loaded fixed full-arch prostheses (380 patients, mean observation period: 23.5 months). In 193 arches (40%), either technical (30.9%), biologic (6.5%), or both (3.1%) types of complications occurred. Technical complications occurred significantly more often than biologic complications (P < .000). The most frequent technical complication was “fracture of veneering material” (24.7%, arch level). The most frequent biologic complication was “marginal bone loss ≥ 2 mm” (16.3%, implant level). The median first advents of technical complications were after 23/26 months (implant/prosthesis-related) and after 3 months for biologic complications, respectively. There was no significant difference of the mean complication rates between the maxilla and the mandible (P = .409). In 99.0% of the arches with complications, the restorations could be obtained. Conclusion: Within this treatment concept, biologic and technical complications may occur over time. However, the vast majority of complications (99.0%) do not affect the overall prosthesis survival. Technical complications are assumed to occur significantly more often than biologic complications. It is suggested that not only stress and material fatigue but also function is a matter concerning this treatment option and, thus, may be a factor related to complication rates.

Keywords: immediate function, immediate implants, immediate loading, immediate placement, implant

Implant-supported immediately loaded fixed full-arch prostheses are well evaluated as a viable treatment option for the restoration of the edentulous arch. These restorations enable a screw-retained one-piece full-arch prosthesis that can only be removed by the dental professional and, thus, are meant to allow for higher patient satisfaction than removable prostheses. These kinds of prostheses are usually made of an acrylic base, a special framework, and esthetic as well as functional prosthetic teeth.

Satisfactory data exist on mid- and long-term implant survival rates concerning the full-arch immediate restoration concept. However, only a little is known about the specifications of complications that may occur over time and the moment they occur.

According to a recent review on complications with fixed implant rehabilitations, it is known that complications do occur and that there are two main types of
possible complications that may be encountered in
general and full-arch implant dentistry: biologic and
technical complications.8,9 Biologic complications refer
to adverse peri-implant soft and hard tissue reactions
(eg, dehiscences), including implant failure. Technical
complications are meant to be separated into two frac-
tions: implant-related and prosthesis-related. Implant-
related technical complications include interferences
of the connective parts between the implant and the
prosthesis (eg, abutment screw loosening) as well as
the implant itself (from a mechanical point of view).
Prosthesis-related technical complications, on the
other hand, refer to complications that are related to
the prosthesis itself (eg, chipping of the veneering ma-
terial). In this context, the previous literature on that
yielded that prosthesis-related fractures such as chipp-
ing of the veneering material occur more often than
biologic problems.8 However, it was concluded that
neither technical nor biologic events are necessarily
related to the loss of the implants or the failure of the
prosthetic work but may easily result in extended com-
plexity of the treatment case.

Meaningful data on the clinical outcome of implant
treatment are considered to include data that are equal
to or beyond an observation time of at least 5 years.10
It is well-known that biologic and technical complica-
tions are present over time and do occur in implant
dentistry, but in particular, complication-specific data
on immediately loaded situations and their moment of
appearance in the long term are scarce.8

Therefore, the aim of this 6-year retrospective in-
vestigation was to evaluate the incidence and the
moment of appearance of biologic and technical com-
plification rates occurring in patients being treated with
implant-supported immediately loaded fixed full-arch
prostheses supported by both axial and tilted im-
plants. Furthermore, there was a focus on the differ-
entiation between the complications for restorations
being placed in either the maxilla or the mandible and
between technical and biologic complications.

MATERIALS AND METHODS

Study Design and Patient Cohort
This retrospective case cohort study on implant-supported
immediately loaded fixed full-arch prostheses was per-
formed in a dental clinic specializing in implantolog-
y (Implaneo Dental Clinic). Patient screening took
place for the period between February 2007 and De-
cember 2013. Only patients who have been rehabil-
itated in the maxilla, the mandible, or in both, by means of
implant-supported immediately loaded fixed full-arch
prostheses using four to six implants per arch, were in-
cluded. Only patient records with a clear description
of the treatment characteristics (eg, dental evidence,
treatment indication, date of surgery) and a thorough
and present documentation of complications that oc-
curred were included. All patients provided written
consent for their participation in the present investiga-
tion. The same cohort was already described and
investigated in the study of Niedermaier et al.11 The
inclusion and exclusion criteria are mentioned below.

Patient Selection
The inclusion criteria were as follows:

- Patients over the age of 18 years of both sexes and
  any race
- Severe atrophy of the maxilla or mandible in the
  posterior regions
- Prior to treatment, a decision toward an immediately
  loaded implant-supported fixed complete dental
  prosthesis had to be made.
- Patients had to be physically and psychologically
  able to tolerate conventional surgical and restor-
  ative procedures.
- Arches treated either had to be edentulous or the
dental status was severely compromised.

The exclusion criteria were as follows:

- Patients providing the following general con-
  traindications for implant treatment: myocardial
  infarction (≤ 6 months); immunosuppression;
  bleeding issues without sufficient treatment; ac
  cidental infection or inflammation in the area of
  any race
  othe
  - Severe parafunctional habits such as bruxism and
  clenching

The study respected the principles of the Declara-
For immediate loading, an insertion torque of ≥ 30 Ncm of the implants was targeted. If primary stability was reached in four implants, no more implants were inserted. If one or two of the axial implants did not attain that amount of insertion torque, immediate loading was still performed due to the splitting of the restoration, and if bony conditions allowed, one additional implant was placed in the premaxilla or the interforaminal mandible. If any of the tilted implants did not reach this torque value, the insertion of additional distally placed implants was aimed. If these additional implants reached primary stability, full-arch dentures were realized. If these implants did not reach primary stability, a submerged healing of these implants was realized and immediate loading was not performed (and thus not included in this investigation). Therefore, the projected implant number was four implants per arch but was raised to five or six when necessary. For prosthetic connection, the abutments used in the anterior/mesial implants were either straight or had an angle of 17 degrees. The posterior/distal implants were provided with angled abutments (17 or 30 degrees), depending on the amount of implant tilting. Healing caps were positioned on the abutments prior to suturing the flaps.

The mucoperiosteal flaps were sutured with a Key-dent ePTFE USP 3/0 (American Dental Systems). Evert-ing mattress sutures and double sling sutures were performed in order to adapt the margins of the flaps.

Concerning the prosthetic procedure, a pickup impression and an interocclusal registration were performed. The screw-retained full-arch acrylic resin prostheses were delivered to each patient within the same day. Immediate loading of the prostheses was targeted with 12 units per arch but with a minimum of 10 units regarding the esthetic appearance (depending on the length of the cantilever). Static occlusion consisted of central contacts established on all masticatory units but the cantilevers for the first 3 months. Dynamic occlusion included canine/premolar guidance, irrespective of the opposite arch conditions. After immediate loading, articulation was checked and panoramic radiographs were obtained to verify implant positioning and the coupling between the prosthetic components. Screw access holes were covered with provisional resin (Fermit, Ivoclar Vivadent). In case of buccally emerging screw-access openings, composite resin was used to achieve an acceptable esthetic appearance. After 1 week, reinforcing frameworks (non-precious metal, zirconia platelets) were assembled into the acrylic resin prostheses.

Postoperatively, an orthopantomogram was made and antibiotics (amoxicillin 875 mg and clavulanic acid 125 mg, two times per day) were prescribed for 5 days. Analgesics (ibuprofen 600 mg, not exceeding the maximum individual dose) were prescribed as required. Mouthrinsing with a 0.1% solution of chlorhexidine digluconate was prescribed for up to 2 weeks after surgery. Patients were advised to brush the artificial dentition with a soft toothbrush and to follow a soft diet for the first week.

After 1 week, patients presented for suture removal, wound examination, and assembling of the prosthetic reinforcement of the frame. Reinforcement of the prosthesis was performed by grinding the prosthesis hollow at the base, which was followed by the adjustment of the framework and the reconnection of the interfaces with a framework-specific connector and poly(methyl methacrylate). According to laboratory design issues of the prosthesis, the reinforcement was either made out of nonprecious metal or out of zirconia. After 3 months,
patients returned for relining of the prostheses. Furthermore, patients were advised to present three times per year for visitation at the dental hygienist following a clinical implant investigation by a dentist. Radiographic examinations were performed when clinically indicated.

**Data Collection**

Descriptive clinical data were ascertained concerning the following factors:

- Sex (male, female)
- Age (years; mean ± SD [min/max])
- Observation period (months; mean ± SD [min/max])
- Smoking behavior (yes, no)
- Treatment-specific data (which arch [maxilla, mandible, double arch], number of supporting implants)
- Dental hygiene behavior

Patient data were screened for the following complication classes (Fig 2):

**Technical complications:**
- Implant-related: implant fracture, abutment fracture, abutment screw loosening, prosthetic screw loosening
- Prosthesis-related: framework fracture (provisional/definitive), fracture of veneering material, reassembling of teeth

**Biologic complications:**
- Implant loss
- Marginal bone loss ≥ 2 mm (measurements via orthopantomograms [OPGs; OPGs were retrospectively measured by one general dentist when available; distance of marginal bone loss was measured in relation to the first acquired postoperative OPG])
- Abscess
- Dysesthesia
- Sinusitis

Furthermore, complication classes were screened for their first time of occurrence after surgery and their quantity (minimum and maximum) of occurrences per restoration.

**Statistical Analysis**

Statistical analysis was performed using SPSS version 21 for Windows (IBM). Descriptive data were obtained using the function of frequencies.

For testing homogeneity of variance and normal distribution, the Levene and Shapiro-Wilk tests were used. For the statistical analysis comparing the means of complication frequencies of no more than two groups, the independent-samples t test (for maxilla vs mandible) and the paired-samples t test (technical vs biologic complications) were used.

**RESULTS**

**Descriptive Patient Data**

Descriptive clinical data are given consideration in Table 1. The collected data obtained information on 482 treated arches (maxilla, n = 159; mandible, n = 121; maxilla and mandible, n = 100; number of supporting implants: four, n = 374; five, n = 62; six, n = 46, respectively) in a total of 380 patients (188 men, 192 women; mean age, 61.9 years). The mean observation period was 23.5 months with a minimum and a maximum of 0.2 and 79.2 months, respectively. One hundred forty-one patients were recorded as smokers, while 239 were recorded as nonsmokers. Information on implant numbers and frameworks is given in Table 1. The number of implants that were under investigation are given consideration in a yearly schedule in Table 2 and in a Kaplan-Meier estimator (Fig 3), which depicts implant-related dropouts (four implants dropped out due to the death of one patient; the remaining implants were unaccounted for).
Complications: Descriptive Data

Descriptive data of complications are given consideration in Table 3. On the patient level, 41.4% of the patients with a single-arch restoration and 59.0% with a double-arch restoration experienced a complication. On the arch level, in 289 treated arches, no complications occurred at all (60% of all restorations). One hundred ninety-three treated arches presented with complications over the course of time (40% of all restorations).

Out of these 193 arches, 149 (77.2%) presented with technical complications, 29 (15.0%) with biologic complications, and 15 (7.8%) with both types of complications.

The types of complications that occurred were as follows and are given consideration in Table 4. Implant-related technical complications were experienced in 4.6% of all restorations (implant fracture 0.2%, abutment fracture 0.6%, abutment screw loosening 2.7%, prosthetic screw loosening 1.5%) and had their first occurrence after a median of 23.0 months. Prosthesis-related technical complications occurred in 34.2% of all restorations (framework fracture 2.3%, fracture of veneering material 24.7%, reassembling of teeth 7.3%) and had their median first advent after 10.0 months. Biologic complications were detected in 9.7% of all restorations (implant loss 6.8%, marginal bone loss ≥ 2 mm 5.4% [data on marginal bone loss does not exceed 5 years], abscesses 1.0%, dysesthesia 0.8%, acute sinusitis 0.2%) and had their median first occurrence after 3.0 months.

Complications: Statistical Analysis

Statistical analysis of complication frequencies is given consideration in Table 6. The statistical analysis, comparing the complication rates between the maxilla and the mandible, yielded neither significant differences for complication rates in general (P = .409), nor for technical (P = .524) or for biologic complications (P = .338). A statistically significant difference was found between the mean values of technical and biologic complications with a higher incidence of technical complications (P < .000).

DISCUSSION

The treatment option of implant-supported immediately loaded fixed full-arch prostheses using four to six implants is a conducive method that results in good mid- and long-term outcomes of implant survival rates.1,13–15 However, complication-specific data on immediately loaded situations and their moment of appearance in the long term are scarce.8 This case cohort study evaluated the incidence and the moment of appearance of
biologic and technical complication rates occurring in patients being treated with implant-supported immediately loaded fixed full-arch prostheses using the following classification of complications for fixed implant rehabilitations of edentulous patients: technical implant-related, technical prosthesis-related, and biologic.8,9

Within the observation period of this study (mean 23.5 months/maximum 79.2 months), 40.0% of all restorations experienced at least one complication, whereas 60.0% of the treated arches were completely free of complications. Statistical analysis yielded that 30.9% of all arches experienced technical, 6.0% biologic, and 3.1% both types of complications. Comparing the hereby presented results with cumulated results presented in literature yields comparable values (5-year data: technical complications up to 33.3% and biologic complications up to 20.1%).8 Comparing the incidences of technical and biologic complications, a statistically significantly higher incidence of technical complications ($P < .000$) was found in the present

### Table 3 Descriptive Data of Complications

<table>
<thead>
<tr>
<th>Level</th>
<th>Number</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Patient level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single arch</td>
<td>280</td>
<td>41.4%</td>
</tr>
<tr>
<td>Double arch</td>
<td>100</td>
<td>59.0%</td>
</tr>
<tr>
<td><strong>Arch level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without complications</td>
<td>289</td>
<td>60.0%a</td>
</tr>
<tr>
<td>With complications</td>
<td>193</td>
<td>40.0%a</td>
</tr>
<tr>
<td>Technical complications</td>
<td>149</td>
<td>30.9%/77.2%b</td>
</tr>
<tr>
<td>Biologic complications</td>
<td>29c</td>
<td>6.0%/15.0%b</td>
</tr>
<tr>
<td>Both</td>
<td>15</td>
<td>3.1%/7.8%b</td>
</tr>
<tr>
<td>Complication frequency &gt; 1</td>
<td>88</td>
<td>18.3%/45.6%b</td>
</tr>
<tr>
<td><strong>Manageable complications</strong></td>
<td>191</td>
<td>39.6%/99.0%b</td>
</tr>
<tr>
<td>Complications related to the loss of the restoration</td>
<td>2c</td>
<td>0.5%/1.0%b</td>
</tr>
</tbody>
</table>

Patient level: Complication percentage displays the percentage of patients who encountered a complication. Arch level: In relation to all restorations. aIn relation to all restorations with complications. bTwo patients had their prostheses rebuilt to removable implant-supported prostheses due to dysesthesia (feeling of tension, discomfort) and, thus, were excluded from further statistical analysis.

### Table 4 Complications

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of affected restorations</th>
<th>% of all restorations</th>
<th>Aggregate number of all events</th>
<th>Min/ max per restoration</th>
<th>Mean number per restoration</th>
<th>First advent mean/ median, months (min/max)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical complications</strong></td>
<td>164</td>
<td>34.0%</td>
<td>311</td>
<td>0/11</td>
<td>0.65</td>
<td>–</td>
</tr>
<tr>
<td>Implant-related</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Implant fracture</td>
<td>22</td>
<td>4.6%</td>
<td>29</td>
<td>0/4</td>
<td>0.06</td>
<td>26/23 (1/65)</td>
</tr>
<tr>
<td>Abutment fracture</td>
<td>1</td>
<td>0.2%</td>
<td>1</td>
<td>0/1</td>
<td>&lt; 0.00</td>
<td>1/1 (1/1)</td>
</tr>
<tr>
<td>Abutment screw loosening</td>
<td>3</td>
<td>0.6%</td>
<td>3</td>
<td>0/1</td>
<td>0.01</td>
<td>26.33/26 (11/42)</td>
</tr>
<tr>
<td>Prosthetic screw loosening</td>
<td>13</td>
<td>2.7%</td>
<td>16</td>
<td>0/2</td>
<td>0.03</td>
<td>25/22 (1/57)</td>
</tr>
<tr>
<td>Prosthesis-related</td>
<td>165</td>
<td>34.2%</td>
<td>282</td>
<td>0/11</td>
<td>0.57</td>
<td>13.77/10 (1/61)</td>
</tr>
<tr>
<td>Framework fracture</td>
<td>11</td>
<td>2.3%</td>
<td>11</td>
<td>0/1</td>
<td>0.02</td>
<td>17.82/13 (2/76)</td>
</tr>
<tr>
<td>Fracture of veneering material</td>
<td>119</td>
<td>24.7%</td>
<td>226</td>
<td>0/11</td>
<td>0.47</td>
<td>17.06/14 (1/61)</td>
</tr>
<tr>
<td>Reassembling of teeth</td>
<td>35</td>
<td>7.3%</td>
<td>45</td>
<td>0/3</td>
<td>0.09</td>
<td>7.54/4 (1/37)</td>
</tr>
<tr>
<td><strong>Biologic complications</strong></td>
<td>47</td>
<td>9.7%</td>
<td>61</td>
<td>0/4</td>
<td>0.13</td>
<td>7.44/3 (1/36)</td>
</tr>
<tr>
<td>Implant loss</td>
<td>33</td>
<td>6.8%</td>
<td>42</td>
<td>0/4</td>
<td>0.09</td>
<td>7.56/4.5 (1/31)</td>
</tr>
<tr>
<td>Marginal bone loss ≥ 2 mm</td>
<td>26</td>
<td>5.4%</td>
<td>47a</td>
<td>0/1</td>
<td>0.01</td>
<td>8.17/1 (1/23)</td>
</tr>
<tr>
<td>Abscess</td>
<td>5</td>
<td>1%</td>
<td>5</td>
<td>0/2</td>
<td>0.01</td>
<td>11.2/3 (1/27)</td>
</tr>
<tr>
<td>Dysesthesia</td>
<td>4</td>
<td>0.8%</td>
<td>4</td>
<td>0/2</td>
<td>0.01</td>
<td>2.0/2 (1/3)</td>
</tr>
<tr>
<td>Acute sinusitis</td>
<td>1</td>
<td>0.2%</td>
<td>1</td>
<td>0/1</td>
<td>&lt; 0.00</td>
<td>36/36 (36/36)</td>
</tr>
</tbody>
</table>

Including restorations (arches) affected by both, technical, and biologic complications (only technical: 149; only biologic: 31; both: 15)

*Describing the number of implants; see also Fig 8 and Table 5.
investigation. In the statistical analysis of complication rates between the mandible and the maxilla, no significant difference was yielded ($P = .409$). Thus far, concerning these comparisons, no statistically meaningful data have been presented in literature yet. However, these results are in good accordance with cumulated descriptive data from literature, also showing the trend of more technical than biologic complications and no difference between the complication rates between the mandible and the maxilla.8,16

### Technical Complications

The most frequently occurring technical complication type was the fracture of veneering material with 24.7% (technical, prosthesis-related, Figs 4 and 5) after a mean of 17.06 months. This is in accordance with the results reported in a literature review on biologic and technical complications with fixed implant rehabilitations from Papaspyridakos and colleagues from 2012.8 They reported on cumulative 5-year technical complication rates with up to 33.3% of chipping/fracture of the veneering material.8 In the 2013 study of Francetti and colleagues on complications in full-arch implant-supported rehabilitations (mean observation period 65.36 months), the detachment of veneering material ranged from 10.5% (provisional prostheses, after a mean 4.33 months) to 23.2% (definitive prostheses, after a mean 20.3 months).16 Recent literature suggests that chipping of the veneering material has a relative high incidence8,17–19 and is attributed to multiple factors: material failure (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).20 Furthermore, a crucial step seems to be the moment when patients change from soft to hard diet.1,4,21 Since the neuromuscular working patterns do not seem to change in patients who have been rehabilitated by means of implant-supported immediately loaded fixed full-arch prostheses in both the mandible and the

### Table 5 Descriptive Number of Implants Under Radiographic Investigation Depending on Yearly Time Intervals

<table>
<thead>
<tr>
<th>Investigation interval (mo)</th>
<th>No. of implants</th>
<th>Percentage of implants with MBL ≥ 2 mm$^a$</th>
<th>Percentage of implants with newly developed MBL ≥ 2 mm$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 0 &lt; 12</td>
<td>394</td>
<td>5.8%</td>
<td>5.8%</td>
</tr>
<tr>
<td>≥ 12 &lt; 24</td>
<td>255</td>
<td>8.2%</td>
<td>4.1%</td>
</tr>
<tr>
<td>≥ 24 &lt; 36</td>
<td>203</td>
<td>11.3%</td>
<td>4.3%</td>
</tr>
<tr>
<td>≥ 36 &lt; 48</td>
<td>106</td>
<td>13.2%</td>
<td>5.2%</td>
</tr>
<tr>
<td>≥ 48 &lt; 60</td>
<td>43</td>
<td>16.3%</td>
<td>2.7%</td>
</tr>
<tr>
<td>≥ 60</td>
<td>No further information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

$^a$Including implants with a MBL of ≥ 2 mm of the previous investigation interval.

$^b$Showing only implants that developed the bone loss within this investigation period.

### Table 6 Statistical Comparisons of Mean Values of Complication Frequencies

<table>
<thead>
<tr>
<th>Maxilla vs mandible$^b$</th>
<th>Mean values$^a$</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All complications</td>
<td>0.78 vs 0.69</td>
<td>.409</td>
</tr>
<tr>
<td>Technical complications</td>
<td>0.69 vs 0.61</td>
<td>.524</td>
</tr>
<tr>
<td>Biologic complications</td>
<td>0.14 vs 0.10</td>
<td>.338</td>
</tr>
</tbody>
</table>

$^a$In relation to all restorations.

$^b$Independent-samples t test.

$^c$Paired-samples t test.

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![Fig 4](image-url) Detachment of a complete central incisor in a mandibular restoration.

![Fig 5](image-url) Upper third fracture of a lateral incisor and a canine in a maxillary restoration.
maxilla, as compared with patients with natural dentition, it is assumed that the transfer of the patient’s occlusal plane to laboratory conditions in the articulator is an issue of high importance concerning function. In addition to that, the implementation of other materials and the bonding of the different interfaces (framework, base, teeth) may offer a new approach and should be given consideration in the future.

Further technical, prosthesis-related complications were the fracture of the prosthetic framework (2.3%, after a mean 17.82 months) and the necessity to do a reassembling of the teeth (7.3%, after a mean 7.54 months). The fracture of the framework of implant-supported fixed full-arch prostheses is reported in the literature to happen in 4.9% of all cases (cumulative 5-year estimated complication rates) and does not only occur in the provisional prostheses with a pure acrylic base (after a mean 5.6 months) but also in the definitive reinforced prosthesis (after a mean 42.3 months). In the present investigation (11 framework fractures in total), five of the framework fractures occurred in the early phase without a reinforcement of the prosthesis (‘provisional’ phase, first week), while six fractures occurred in the definitive version with a reinforcement included (five made of nonprecious metal and one made of zirconia, after a mean of 24.5 months; min = 5/max = 76 months). In one framework fracture that was made of nonprecious metal, fracture investigations yielded that the framework was too thin and the fracture was distal of it (laboratory design issue). The possible negative effect of unsupported prosthetic extension was already described by Zurdo et al. Further, the fracture investigation on the framework that was made of zirconia yielded that the frame was probably too thin and therefore can be attributed to a laboratory design issue. The authors suggest that the rest of the framework fractures in the definitive dentures were attributed to material fatigue, while the fractures in the provisional dentures were attributed to the limited strain capacity of the nonreinforced acrylic resin base of the dentures. Concerning the necessity to do a reassembling of the teeth, only a little is known with regard to the classification in technical, prosthesis-related complications. In the present study, teeth of 45 (7.3%) arches needed to be reassembled. Reassembling was initiated either when the patient was subjectively/esthetically dissatisfied or if occlusion was inadequate (as a result of a failing technical transfer).

Implant-related technical complications occurred very rarely compared with prosthesis-related complications. Within this category, abutment screw loosening was the most often detected complication with 2.7%, followed by prosthetic screw loosening (1.5%), abutment fracture (0.6%), and implant fracture (0.2%). These low incidences coincide with the literature that reports on incidences from 0.0% (mean observation period 65.36 months) to 9.3% to 10.4% (cumulative 5-year estimation) concerning these categories. Several reasons such as parafunctions, occlusal overload, cyclic stress, and framework misfit have been suggested to be possible rationales for these occurrences. From a technical point of view, it is assumed that the low incidences of these events are attributed to the conceptual idea of tilting the distal implants and, thus, reducing both the length of the cantilever and the biomechanical stress on the abutments and implants.

**Biologic Complications**

Biologic peri-implant soft and hard tissue complications are well-known to contribute to late implant failure in implant dentistry. Therefore, peri-implantitis is reported to occur in 40% of the implants and 50% of the patients in the medium term. However, within the retrospective limitations of this study, marginal bone loss was measured as an indicator for peri-implantitis since it has been described as a prerequisite for peri-implantitis at a level of ≥ 2 mm. Concerning implant-supported immediately loaded fixed full-arch prostheses, marginal bone loss beyond 2 mm was reported to occur in 17.7% to 22.6% of all implants (cumulative 5-year estimated complication rates). In the present investigation, marginal bone loss beyond 2 mm was only observed in 5.4% of all restorations (in 9.4% of all implants that have been under radiologic investigation, and in 16.3% of all implants under investigation after 5 years). The tendency toward lower incidences of biologic complications corresponds with the results from a study of Francetti et al. on full-arch rehabilitations with upright and tilted implants. There, biologic complications in terms of peri-implantitis reached 10.4% on the patient level, which was attributed to the fact that the cohort was well-maintained. However, the notably low incidences yielded in the present investigation are suggested to be, in particular, the result of implant hygiene (as mentioned in the study of Francetti et al.) and the prosthetic base design. The principles of the prosthetic base design used in this study are a mirror polish at both the base itself and the interface region between the abutment and the denture (Fig 6). Further, the base is designed very flat without any concavities, which is ultimately related to the possibility for proper autonomous domestic hygiene (Fig 7). In addition to that, the controlled cohort was embedded in a standardized follow-up program for implant hygiene (three times per year including oral hygiene instructions/ensuring a 6-year guarantee).

In total, 42 implants failed in the retrospective analysis (2.0% of all implants). The mean instant of time for implant failure was 7.56 months, which coincides with results from a literature review of Patzelt.
and colleagues on fixed implant-supported prostheses, who found that the majority of implants (74%) fail within the first 12 months.1 Implant failure beyond 12 months was detected very rarely in this study (16.7% out of all failed implants). The authors suggest that implant failure within this well-maintained cohort may result from missing osseointegration due to punctual occlusal overload as a result of functional problems. However, likewise, it was reported in the mentioned review that neither of the implant failures compromised prosthesis survival. When an implant failure occurred, either a new one was inserted and immediately integrated in the prosthesis or a new one was inserted followed by a submerged healing and a prosthesis with a shortened dental arch on the residual implants.

Complete prosthesis failure by means of a conversion to removable dentures was experienced in two patients (0.5% of all restored arches; both maxillary single-arch restorations). Both subjects were free of objectifiable dental rationales that might have initiated the rebuilding of the prosthesis, but much more reported on subjective discomfort with the fixed prosthesis.

While implant survival criteria have been well described in the literature,27 the prosthetic treatment outcome including both adverse prosthetic technical and adverse biologic events lacks definition.8 Pjetursson and colleagues described the prosthetic survival as remaining in situ with or without modifications, while success was defined as remaining in situ and free of all complications over the entire observation period.28 In addition to that definition, a differentiation between “real” complications, such as a framework fracture, should be discriminated from events that might be expected over time and that can be described to the patient prior to treatment (such as prosthetic screw loosening). However, to date, there is a lack of uniformity of how complications are reported in implant dentistry, especially in implant-supported immediately loaded fixed full-arch prostheses.8

The condensed evaluation of the mean first advents of the complications yielded, for both types of complications, technical and biologic, that these were within the first 36 months. Therefore, within the hereby presented investigation period of up to 6 years, the authors suggest that for this treatment option, data may already be considered meaningful after 3 years. Furthermore, the treatment progress also may already be evaluated after 3 years, which is contrary to the proposition to consider data in prosthodontics as meaningful only after 5 years of investigation.10

Within the limitations of the retrospective study design, the authors want to state that with regard to both biologic and technical complications, the complication rates might have yielded less good results in restored arches that have been unaccounted for over time, and thus, could not have been evaluated any further (Table 2). In this context, it has to be mentioned that measurements of the marginal bone loss could only be performed in cases where postoperative radiographs were available. Therefore, there is a lack of data
on marginal bone loss beyond 5 years and a number of implants that have been unaccounted for over time (Table 5). Thus, it has to be expected that the results concerning these two factors might have been less good than the presented ones. Concerning technical complications, the present investigation did not allow for a differentiation between “fractures” of the veneering material. Basically, a fracture may occur at three points: within the attached tooth itself (attachment to the base is still intact); the detachment of the complete tooth from the base; and detachment/fracture of the tooth and parts of the base from the framework. However, this is assumed to be an important clinical but also laboratory aspect in technical fault prevention and, thus, should be addressed in the future.

With regard to the factors “abutment screw loosening” and “prosthetic screw loosening,” no differentiation between a real screw loosening and an actual fracture of the screws was made. However, the authors are aware that this is an issue of high interest and will be addressed in the future owing to the necessity of minimized micromovements in terms of an immediate loading protocol. Another crucial aspect that should be investigated using an implant-supported immediately loaded fixed full-arch prostheses protocol will be the complication rates occurring according to different opposing dentitions. Concerning further clinical measurements, it has to be stated that the present publication does not depict probing depths, bleeding on probing, recessions, and esthetic outcome, which all may give more information on success and complications and should be addressed in further publications.

CONCLUSIONS

It is indicated that within such a treatment concept, both biologic and technical complications may occur over time and, thus, diminish the restorative success. Regarding the complication rates, it does not seem to make a significant difference whether the fixed prosthesis was placed in the mandible or the maxilla. The kind of complication shows a significantly higher rate of technical complications compared with biologic complications. In particular, the detachment/fracture of the prosthetic teeth shows an extended prevalence, whereas biologic complications such as implant loss and marginal bone loss are rare. The authors suggest that the key factors for a successful biologic part of treatment are the maintenance of the patients and a specific design concept of the prosthesis (flat base, mirror polished base). However, the vast majority of complications (99%) do not affect the overall prosthesis survival in terms of fixed full-arch prostheses and can be fixed.

Since the condensed evaluation of the mean first advents of the complications yielded that these were within the first 36 months, it has to be discussed whether this timespan may be considered meaningful for this treatment concept. That would mean that the evaluation of this concept and every single treatment progress is not necessarily up to scientific long-term data, which are mostly scarce.

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REFERENCES


