# Prosthetic complications with ITI dental implants. Results from an up to 8-year experience in private practice.

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Key words :

ITI implants, fixed prostheses, removable prostheses, complications, clinical study

## Abstract

The prosthetic rehabilitation of 236 patients with 528 ITI dental implants was evaluated in our 8-year private practice experience. A total of 55 overdentures (OD) and 265 fixed partial dentures (FPD) were placed. Among the latter, 231 FDPs were cemented and 34 were screw-retained. The type and the frequency of prosthetic incidents were recorded, including adjustments and complications. Factors contributing to prosthetic incidents have also been investigated. One abutment fractured and 2 became loose, leading to a cumulative implant component success rate of 99.24%. When it comes to the different types of suprastructures themselves, removable implant-supported prostheses had more incidents/complications than the fixed ones, 66.0% vs. 11.5%; the difference was

significant. Posterior fixed prostheses had more complications than anterior ones, 11.0% vs. 0%; the difference was significant. Cemented prostheses had more complications than screw-retained ones, 10.4% vs. 5.9%; the difference, however, was not significant. Prostheses with an extension (cantilever) had more complications, 29.4% vs. 7.9%; the difference was significant. In the OD group, the ball-anchored ones had more complications than the bar-retained ones, 77.5% vs. 42.9%; the difference was significant. Major differences were found between the FPD and OD groups. In the FPD group, complications were not recurrent; most of them happened during the first 2 years and did not increase with time. After 1, 2, and 3 years of loading the percentage of complication-free fixed prostheses was 95.6%, 93.9% and 93.1%, respectively. The cumulative percentage of complication-free prostheses was 88.5%. In the OD group, 1.29 incidents per prosthesis were recorded. The incidents were often recurrent and did not decrease with time. After 1, 2, and 3 years of function the percentage of incident-free OD was 74.5%, 64.7% and 44.0%, respectively.

# Introduction

The biological predictability of dental implants has been extensively documented for all types of indications, including the edentulous and the partially edentulous upper and lower jaws. Prosthetic complications associated with 2-stage Brånemark [1-17] and the 1-stage ITI implants [18-25] have been assessed. However, the studies having specifically addressed the prosthetic complications on ITI implants have been carried out in hospital clinics and university centers. Studies performed in these settings have often involved predefined patient selection [26-29] in order to get homogeneous populations of patients. This might bias the real picture of implant treatment since worldwide most implants are placed in a private practice environment. In private practice, the practitioners wish to treat all patients that require a fixed rehabilitation. This population includes all types of edentulism, patients in different health conditions, as well as patients with bruxing and clenching habits.

There is scarce information on the prosthetic rehabilitations supported by 1-stage ITI implants and the complications that may occur in a heterogeneous population treated in a private practice with increasing time of function. In a previous long-term study [30], the survival rate of ITI implants was investigated in a non-specialized private practice setting, with emphasis on short implants; the cumulative success rate at 7 years was 99.40%. We presently report the prosthetic complications of the

same group of implant-supported and implant-tissue supported [31] rehabilitations while all have been now in function for 3 to 8 years. The aim was, therefore, to document the type, frequency and incidence of complications and determine the factors that may predispose to prosthetic incidents.

# Material and Methods

### Patients and prosthetic rehabilitations

Between January 1995 and December 2000, 236 patients (mean age 57.5 years) have been rehabilitated with 528 ITI implants and the respective prostheses; 145 females (61.4 %) and 91 males (38.6 %). Wide inclusion criteria have been used [30] to provide the benefit of implant therapy to the largest number of patients.

Patient age at implant placement ranged between 18 and 89 years. Patients younger than 50 years received 176 (33.3 %) implants, patients between 50 and 70 years received 278 (52.6 %) implants, while 74 (14.0 %) implants were placed in patients that were older than 70 years. The patient pool included bruxing (26 patients / 72 implants; 13.6 %), smoking (52 patients / 106 implants; 20.1 %) and medical risk patients (31 patients / 77 implants, 14.6 %) like HIV+, controlled diabetes, malignant pathology other than in the cervico-facial area, heart disease or patients with coagulation deficiency. Bruxers rehabilitated with FPDs received 1

implant per rehabilitated unit and flattened cuspids were preferred without, however, any further extra-attention like night-guards.

Up to the second semester of 1999, titanium plasma-sprayed (TPS) implants have been used. From then on exclusively sandblasted and acid etched (SLA) implants have been inserted, accounting for half (264; 50.0 %) of the placed implants. 465 (88.1 %) implants were standard implants of Ø 4.1 mm at the bone level and Ø 4.8 mm at the implant collar, 16 (3.0 %) were reduced diameter implants of 3.3 mm at the bone level and Ø 4.8 mm at the implant collar, 13 (2.5 %) were narrow-neck implants of Ø 3.3 mm at the bone level and at implant collar, 34 (6.4 %) were wide-neck implants of Ø 4.8 mm at the bone level and Ø 6.5 mm at the implant collar. Most implants rehabilitated the posterior region (premolar and molar area), 42.8 % rehabilitated the posterior mandible and 23.7 % the posterior maxilla as shown in table 1. 305 (58.6 %) implants were ≤ 10 mm, lengths have been detailed elsewhere [30]. The mean implant length for the removable prostheses group was 11.1 mm; for the fixed prostheses group it was 10.0 mm.

Edentulous patients in the mandible, wearing a removable prosthesis in the maxilla, were rehabilitated with an implant-tissue supported overdenture [31] retained by 2 spherical attachments connected to 2 implants, rarely with magnetic attachments (1 patient). Implant-supported overdentures [31] relying on 4 implants connected with bars were indicated in the following cases, 1) edentulous patients in the mandible having maintained their opposing natural dentition, 2) edentulous

patients in the mandible wearing a fixed appliance in the maxilla, 3) edentulous patients in the maxilla, 4) immediately loaded implants in the mandible. When the pre-existing removable prosthesis was considered functionally, mechanically and esthetically sound, it was kept and relined accordingly, after placement of the retentive elements.

Partial edentulism in the posterior area was treated preferably with 2 splinted implants, including a pontic when feasible. In the latter situation, placement of 2 implants on each end of the edentulous gap alleviated surgical placement planning (precise inter implant distance placement is not requested), eased the prosthetic reconstruction (possible variation of pontic and crown mesio-distal dimension) and reduced the rehabilitation costs (2 implants instead of 3). Extensions (cantilever) units were used when the crest was too thin to receive an implant or when the available bone height was insufficient.

Assessment of the prosthetic reconstructions included the following information: position in the oral cavity, number of implants, number of prosthetic units, presence of extension and pontics, and fixation mode i.e. screw-retained or cemented. The prostheses distribution is detailed in table 2. Implants supported single crowns (SC : 32.4 %), fixed partial dentures (FPD : 38.6 %), fixed full arches (FFA : 1.1 %) and overdentures (OD : 27.5 %); 2 FPDs with 1 implant each were implant-tooth supported. The mean number of implants per FPD was 2.27 in the mandible and 2.07 in the maxilla. Details related to FPDs are given in table 3. The majority of the splinted FPDs (90.3 %) were supported by 2 implants, 25.8 % of them consisting in

2 splinted implants. The other FDPs supported by 2 implants had one (49.5 %) or two (3.3 %) pontic units, a extension (cantilever) unit (16.1 %) or both (3.3 %). In the fixed prosthesis group, cementation was performed at 85.4% of the implants; screw-retention was indicated when the crown-implant junction was located distinctly sub-mucosally for esthetic reasons.

**Prosthetic complications**

All prosthetic events, adjustments and complications were recorded. In the removable prosthesis group, the recorded events included adjustments and repairs. Repairs were divided into foreseeable and unforeseeable repairs. Adjustments were activation of the female part of the spherical attachment and of the clip. Foreseeable repairs were change of the female part of the spherical attachment, change of the clip and relining. Unforeseeable repairs were mechanical retention problems (antero-posterior rotation of the prosthesis), repair and replacement of the overdenture and complications of the opposing full denture.

In the fixed rehabilitation group, complications included prosthesis debonding, abutment loosening and screw loosening, abutment fracture as well as fracture of the porcelain veneer. Fracture of the porcelain veneer was divided into minor and major fractures. A fracture was considered a major one when either one or several of the following events were recorded: affected esthetics, visible metallic framework, missing inter-proximal contact point, and the patient complaining about

tongue or mastication discomfort; they all led to prosthesis remake. A fracture was considered a minor one when esthetics was not affected, when the metallic framework was not visible, when the interproximal point was not involved and when the patient did not complain about tongue or mastication discomfort; they did not lead to prosthesis remake.

**Prosthetic parameters**

To determine the factors that may predispose to a prosthetic problem, the following occlusal and functional parameters were assessed: prosthesis type (fixed or removable), fixation mode (cemented or screw-retained), presence of an extension (cantilever); location in the oral cavity and bruxing habits.

**Statistical analysis**

Frequency and time of occurrence have been recorded for each complication type. An 8-year life-table analysis with the cumulative percentage of incident-free prostheses was calculated. The percentage of incident-free prostheses at 1, 2 and 3 years was also determined. The Chi-square test was used to identify the risk factors associated with the complications. The threshold value for significance was set at 5%.

# Results

Overall three biologic failures in two patients were recorded: one early failure (0.2 %) before loading and two late failures (0.4 %) after 1 and 12 months of loading; the cumulative survival rate was 99.40 %. This remained unchanged since our previous report [30] on these implants. All failed implants were in the mandible, no failure occurred in the maxilla. Twenty four prostheses (7.5 %), 4 OD, 4 FPDs and 16 SCs were lost to follow-up. The respective reasons have been previously listed [30].

**Fixed prostheses group**

The fixed prostheses group consisted of 265 prostheses and 383 implants (72.5 % of all implants). 87.2 % of the 265 prostheses were cemented and the majority (86.4 %) of the prostheses rehabilitated the posterior region. In the anterior region, the cemented prostheses represented 44.4 %, i.e. the majority of the prostheses (55.6 %) were screw-retained. In the posterior region, the cemented prostheses represented the vast majority (93.9 %) of the fixed prostheses.

Complications that occurred to the fixed group are listed in table 4. One abutment fractured after 42 months of loading, 2 abutments became loose after 8 and 10 months, all supporting single molar crowns. These abutments and crowns had to be changed. Prosthesis debonding was recorded for 4 implants in 3 patients, 2

single molars in the mandible after 9 and 41 months, a 3-unit bridge in the maxilla supported by 2 implants with a mesial extension (cantilever) after 20 months; all abutments were 4 mm in height. Two of them were occlusally shortened to create the necessary room for the prosthesis and one was considered too short with regard to the crown height. Screw loosening was not recorded at any of the 34 screw-retained prostheses. No complications were recorded in the anterior region.

Eighteen prostheses (15pat/25impl) revealed a porcelain fracture, 2 (2pat/3impl) of them were screw-retained and 16 were cemented. For 13 prostheses the veneer fractures were minor ones; and 5 had major ones. The minor fractures were recorded in 10 patients, 4 males and 6 females, and the major ones in 5 patients, 3 males and 2 females; 3 out of these 15 patients were bruxers. The minor fractures happened after 4 to 68 months of function (mean 22 months). These incidents were observed in the posterior region only; 8 in the maxilla and 7 in the mandible. In the maxilla, the affected sites were 4 molars and 4 premolars, in the mandible, 1 premolar and 6 molars. The major porcelain fractures happened after 5, 11, 18, 31 and 40 months. Nine prostheses involving 13 implants were replaced for 2 males and 6 females; the causes were abutment fracture (1impl/1prosth/1pat), abutment loosening (2impl/2prosth/2pat), major veneer fracture (10impl/6prosth/5pat). 8.5 % of the single molars and 7.1 % of the single posterior (premolar and molar) restorations had a prosthetic complication. The cumulative percentage of complication-free prosthetic ITI components at 8 years was 99.2 %. 90.2 % of the prostheses were free of incidents. All events occurred only once. 3.9 % of the posterior prostheses were replaced. The percentage of complication-free

prostheses after 1, 2 and 3 years of loading, was 95.6 %, 93.9 % and 93.1 %, respectively. The cumulative percentage of complication-free prostheses was 88.5 % as shown in table 6.

FPDs in the posterior region were more prone to complications than in the anterior region (11.0 % vs. 0%); the difference was statistically significant. The complication rate was higher for the cemented prostheses group than for the screw-retained one (10.4 % vs. 5.9 %); however the difference was not statistically significant (Table 5). Prostheses with extension (cantilever) units underwent more complications than prostheses without extensions (29.4 % vs. 7.9 %) as shown in table 5; the difference was statistically significant. Presence of an extension could be identified as a complication risk-factor. Most complications (85.7 %) occurred in non-bruxing patients. Within the group of bruxers having received a fixed prosthesis (18 pat/49 impl), 83.3 % were free of complications. A bruxing habit could therefore not be identified as a complication risk-factor ($p > 0.05$) as shown in table 5.

**Removable prostheses group**

This group consisted of 55 prostheses and 145 implants, divided into 41 ball-anchored prostheses and 14 bar-anchored ones. Half of the bar-retained prostheses were immediately loaded. The pre-existing prostheses were kept for 60 % of the patients (33 pat/80 impl).

In the ball-anchored group, 28 (68.3 %) out of 41 prostheses were re-used, while in the bar-retained group 6 (42.9 %) out of 14 were re-used. The number and the type of interventions are listed in table 4. Several incidents might have occurred at the same prosthesis. Adjustments were divided into reactivation of the female attachment (10impl/5prosth), reactivation of the clip (12impl/4prosth). Foreseeable complications were defined as replacement of the female attachment (33impl/19prosth), clip replacement (12impl/3prosth) and prosthesis relining (48impl/21prosth). Unforeseeable complications were defined as lack of prosthesis stability around the horizontal axis (8impl/4prosth), magnet wear (2impl/1prosth), tooth fracture on the prosthesis (3impl/2prosth), prosthesis fracture that needed repair (12impl/5prosth) or prosthesis remake (2impl/1prosth). The fixed components retaining the prostheses were also evaluated. No complications happened to the ITI spherical anchors. One extension bar fractured while no further complication happened to the underlying bar components. All other complications happened to the removable part of the prosthesis and not on the fixed retention components.

The mean number of events per prosthesis under follow-up was 1.29. It varied from 1 to 5. The percentage of prostheses free of any incident was 34.0 % and 2.0 % of the prostheses were remade. After 1 year of loading, 76.4 % of the prostheses were free of incidents. After 2 years of loading they were 64.7 %, and 44.0 % after 3 years. The cumulative percentage of incident-free prostheses was 10.23 % (table 7a). In the group that required a prosthetic action, 48.6 % underwent a single event, 27.0 % underwent 2 events, 13.5 % had 3 events and

10.8 % underwent 5 events. The first incident happened for 33.3 % of them during the first year, 22.2 % occurred between the first and second year, 27.9 % happened during the second year of loading and 16.6 % happened later. When the unforeseeable events only were considered instead of all events, the cumulative percentage of incident-free prostheses was 77.20 % (table 7b).

Similarly, when the ball- and bar-anchored prostheses were analyzed separately, the number of events per prosthesis was 1.50 for the ball-anchored rehabilitations and 0.93 for the bar-anchored ones. Only 24.4 % of the ball-retained prostheses vs. 57.1 % for the bar-retained ones were free of incidents; the difference was significant (Table 5). In the ball-anchored group, 72.5 % of the prostheses were free of incident after 1 year of loading; after 2 and 3 years of loading these values were 52.5 % and 37.5 %, respectively. Half of them underwent 3 events, the highest number of recurrent events. In the bar-retained group, 92.9 % of the prostheses were free of incidents after 1 and 2 years and 71.4 % after 3 years of function. The prostheses subjected to 1, 2, 3 and 5 recurrent events were 54.8 %, 25.8 %, 6.4 % and 12.9 %, respectively.

Most complications (77.4 %) did not happen to bruxing patients. Within the group of bruxers that received an overdenture (8pat/22impl), 75.0% had an incident. In the non-bruxing group, 62.8 % of the patients had such an incident. A bruxing habit could not be identified as a parameter associated to incidents ($p > 0.05$) as shown in table 5.

# Discussion

In this patient population issued from a private practice, all prostheses have been in function for at least 3 years. During a period of implant use of up to 8 years, complications with ITI prosthetic components (abutments, occlusal screws) were a rather rare event. One abutment fractured and 2 became loose, leading to a cumulative prosthetic component success rate of 99.24 %. The screw portion of the broken abutment could be recovered by ultra-sonic mobilization and did not require the use of the repair set described by Luterbacher et al. [32]. The abutment that broke after 42 months of function was placed in 1997; Mericske-Stern et al. [23] related this type of complication to a material problem that was not observed for abutments manufactured before or after 1997. The posterior area, and more specifically, single crowns in the molar area were subject to complications, in line with other studies [23]. To avoid the risk of abutment loosening, adjacent single crowns were splinted into 2-or 3-unit FPDs, representing 28.0 % of all FPDs. This splinting eased also prosthesis removal when needed after a major veneer fracture.

The number and frequency of events were different for the fixed and the removable groups; the removable prosthesis group underwent much more incidents (66.0 % vs. 11.5 %) as shown in table 5; this finding is in accordance with other studies [5,25, 33, 34]. In the removable group, the mean number of events (i.e. all events including

adjustments, foreseeable and unforeseeable complications) per prosthesis was 1.29 ; 34.0 % of the prostheses have been free of incidents. In the fixed group, 90.2 % of the prostheses were incident-free. There was no recurrent incident in the fixed prosthetic group while in the removable group 51.3% of the incidents were repetitive, up to 5 times. In the latter group, the events, although numerous, had less financial significance and could be easily taken care of; only 1 (2.0 %) prosthesis had to be remade. Noteworthy, when the unforeseeable events only were considered, 74.0% of the prostheses were incident free, the number of incident per prosthesis was reduced to 0.27 as shown in table 8**,** and there was no recurrent event. Under the latter conditions, the difference between the fixed and the removable group is no more salient as when all incidents are accounted, stressing that the adjustments and foreseeable events are mostly contributing to the prosthetic incidents.

Within the removable prostheses, the bar-retained group had fewer complications than the ball-retained one (42.9 % vs. 77.5 %). At 3 years, the incident-free prostheses rate was 71.4 % for the bar-retained group vs. 37.5 % for the ball-retained one. The occurrence of adjustments, foreseeable and unforeseeable complications should be mentioned as expected events associated with the treatment. This means that after prosthesis delivery, patients treated with a removable prosthesis are expected to require additional attention and follow-up. Because several incidents are foreseen, the costs associated with the maintenance of an implant–supported overdenture should be incorporated in the overall treatment costs during treatment planning. In the fixed group on the other

hand, the distinction between foreseeable and unforeseeable incidents is irrelevant, thus all incidents should be considered unforeseeable. This means that after delivery a fixed prosthesis is not expected to require any further attention. The number of complications was low indeed, but 37.5 % of the complications led to expensive prosthesis replacement with 3.4 % of the prostheses changed.

In a 36-month loading survey, Duncan et al. [25] provided distinct complication rates for cemented and screw-retained prostheses supported by ITI implants. For the screw-retained prosthetic group, 35.7 % of the prostheses had a complication (loose occlusal screws, no porcelain veneer fracture) while the cemented group was complication free. Similarly, Levine et al. [24], in a 1 to 78 months survey on posterior single crowns placed on ITI implants, recorded more complications at the screw-retained prostheses than at the cemented ones, 19.7 % vs. 1.8 %, without veneer fracture for the screw-retained implants. In the present study with all prostheses having been in function for at least 3 years, the cemented prostheses were subject to more complication than the screw-retained ones, 10.4 % vs. 5.9 %, although the difference was not significant. At the 3-year follow-up, more complications were recorded for the cemented prostheses than for the screw-retained ones, 7.0 % vs. 2.9 %. In addition, screw loosening was not recorded. The lack of screw-loosening might be related to the fact that most of the screw-retained prostheses (72.3 %) rehabilitated the anterior region where the mechanical environment is less demanding. Indeed, for screw-retained single crowns placed mostly (92.1 %) in the posterior area, Mericske-Stern et al. [23] reported a rate of 18.6 % of screw loosening during the first year.

Some authors [25] suggested that complications are likely to arise after 3 years of loading, as the function time of the prostheses will increase. For FPDs, however, Behneke et al. [19] in a 5 year survey and our present 8-year experience do not convey data in this direction. Several groups observed most complications during the first year [16,19,21]. Because the number of events does not seem to increase with time over an 8-year period, the low occurrence of biologic and prosthetic events may suggest that the need for screw-retained prostheses to assure retrievability and thus facilitate re-intervention is of limited relevance. This is strengthened by the fact that screw-retained rehabilitations in the posterior region are expected to face a higher complication rate than cemented ones, especially during the first year of loading [16,23,25]. Noteworthy, the cemented solution is more cost effective and renders implant therapy more affordable to a larger number of patients. In our practice, the screw-retained solution was proposed only in anterior esthetic cases where the prosthetic-implant interface was distinctly sub-mucosally located, to avoid problems consecutive to cement diffusion in the soft tissues.

The complication rate for the single crowns placed in the posterior area was 7.3 %. Other authors reported higher complication rates in the 10-20 % range [13,17,23] . However, most of them have been related to occlusal screw loosening without significance for the prosthesis integrity. In the present report, porcelain fractures occurred in 7.3 % of the prostheses; noteworthy, neither gender nor jaw localization (mandible vs. maxilla) played a role in fracture occurrence. Some studies reported no veneer fracture after 3 years [25] or 5 years of loading [19], or this

complication was a rare event [23] with 1 fracture for 107 single crowns placed in the posterior region (0.9 %). On the other hand, higher fracture rates have also been reported; Wennerberg et al. [16] recorded 55 fractures for 359 (15.3 %) implants. Vermylen et al. [17] had 5 fractures for 43 implants (11.6 %) and Brägger et al. [21] reported 11 ones for 103 implants (10.6 %). Brägger et al. [21] were able to associate veneer fracture and bruxing patients. However, this correlation was not presently confirmed, despite the lack of night-guards. It is possible that cuspid flattening helped to reduce the occurrence of porcelain fractures. Nevertheless, the reason for the difference in veneer fracture between the various studies remains to be identified. It might be related to inadequate laboratory technique as well as to insufficient attention paid to occlusion management. No difference in pattern could be identified between the private practice and the university centers. It is worth noting that even in the removable group, the bruxing patient could not be identified as a parameter of incidents.

In the removable prostheses group, the number of adjustments was 0.18/prosthesis, the number of foreseeable complications was 0.84/prosthesis, and the number of non foreseeable complications was 0.27/prosthesis for a total of 1.23 incidents per prosthesis. Wear of the retaining components (40% of the prostheses), prosthesis relining (38.2% of the prostheses) and reactivation of the attachment (16.4% of the prostheses) were the highest contributors to the prosthetic incidents. Intuitively, attachment activation and prosthesis wear might have been regarded as inevitable events. However, our present data invalidate this assumption since 83.6 % of the prostheses did not require attachment activation

and 60 % did not have their attachment replaced. The fact that the majority of the prostheses were not concerned by these complications suggests that attachment weakening or wear is not inevitable but is probably related to other unidentified variables that remain still to be determined under finer parameter scrutiny.

Our prosthetic approach was to change the female parts at both supporting implants even when only one showed signs of wear. In addition, when a prosthesis was subjected to any repair, the female parts were changed and the prosthesis was relined. In the group of ball-anchored overdentures, the number of adjustments and complications were maintained at a consistent level over time. For overdentures in the maxilla, anchored on screw-retained bars, Kiener et al. [22] noted that complications were concentrated during the first year and then abated. It should be stressed that those rehabilitations were implant supported overdentures whereas the present prostheses were in majority (74.5 %) implant-tissue supported overdentures [31] relying on 2 spherical anchors.

Prosthesis fracture happened to 5 (10.0 %) patients. Metallic reinforced prostheses would probably have decreased this complication occurrence. However, metallic reinforcement was not originally felt to be necessary in presence of a bulky prosthesis and when the mastication forces were limited in intensity, i.e. when the antagonist was a removable prosthesis. No complication was recorded at the ITI components, either the spherical abutments or the retaining elements of the bars. It is interesting to observe that the retentive (fixed) part of the removable prosthesis underwent a single incident, a fracture of an extension bar after 3 months of

function, while the mobile part was responsible for all other incidents.

The biologic incidents, failures and peri-implantitis, of the same implants have been previously followed over a 7 year period [30]. It was found that in addition to 1 early and 2 late failures, 6 implants were subjected to peri-implantitis; 2 implants were supporting ODs and 4 were sustaining FPDs. Further to this report, the implants did not undergo any additional biological incident. Therefore, the combination of these 2 reports can provide an interesting insight, covering all incidents, biological and prosthetic ones, that can happen to an implant-supported rehabilitation. Table 9 and 10 relate, for the fixed and the removable prostheses respectively, a cumulative incident-free (biologic and prosthetic) implant treatment rate with the prosthetic rehabilitation as a unit. Comparisons with table 6 and 7 show that the figures are very close; they put into evidence that the main incident contributor to implant-supported rehabilitation is prosthetically related rather than biologically related. In a literature review, Goodacre et al. [33,34] reported that a greater number of clinical complications was associated with implant-supported prostheses when compared to teeth-supported prostheses. For the removable prosthesis group, our study supports this conclusion. However, for fixed rehabilitations, these complication figures are well inferior. Our data suggest that fixed implant-supported rehabilitations are less linked with complications of any type.

# Conclusion

After 8 years with 528 implants in 236 patients, the cumulative prosthetic component success rate for the ITI implant system was 99.24 %. The removable and fixed prostheses groups displayed different types and frequencies of events. In the removable group, the adjustments and the foreseeable complications were numerous, recurrent and mostly easy to manage. Their number did not decrease with time and the cumulative percentage of incident-free prostheses, including the foreseeable and the unforeseeable ones, was 10.23 % after 8 years. The bar-retained prostheses had fewer complications than the ball-retained ones. In the fixed group, complications were limited in number; they were not recurrent and did not increase with time. Complications were restricted to the posterior region. The cumulative percentage of complication-free prostheses was 88.51 % after 8 years. Finally, results in our private practice compares well with the results obtained at university centers.

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Table 1 Implant distribution according to the jaw and the region.

| | Anterior | Posterior | Total |
|---|---|---|---|
| Maxilla | 76 (14.4 %) | 125 (23.7 %) | 201 (38.1 %) |
| Mandible | 101 (19.1 %) | 226 (42.8 %) | 327 (61.9 %) |
| Total | 177 (33.5 %) | 351 (66.5 %) | 528 (100 %) |

Table 2 Distribution of the prostheses in the mandible and in the maxilla.

| | Maxilla | | Mandible | | Total |
|---|---|---|---|---|---|
| Overdenture | 8 | | 47 | | 55 |
| Full Arch bridge | 1 | | 0 | | 1 |
| Fixed partial bridge | 30 | | 63 | | 93 |
| Single Crown | ant | post | ant | post | |
| | 14 | 86 | 1 | 70 | 171 |
| Total | 139 | | 181 | | 320 |

Table 3 Detailed distribution of the FPDs according to the presence of pontics and extension cantilever.

| | supported by 2 implants | | | | | supported by 3 implants | | | | supported by 4 implants |
|---|---|---|---|---|---|---|---|---|---|---|
| Prosthesis type | 2 units | 2 units + 1 cantil. | 2 units + 1 pontic | 2 units + 2 pontic | 2 units + 1 cantil. + 1 pontic | 3 units | 3 units + 1 cantil. | 3 units + 1 pontic | 3 units + 2 pontic | 4 units + 1 cantil. + 1 pontic |
| nb | 24 | 11 | 45 | 2 | 2 | 2 | 4 | 1 | 1 | 1 |

Table 4 Details of the adjustments and complications for the removable and fixed prostheses groups.

| Removable prostheses | | Fixed prostheses | |
|---|---|---|---|
| Events | Implants / Patients / Prosthesis | Events | Implants / Patients / Prosthesis |
| Adjustments | | Complications | |
| Reactivation of attachment | 10 i / 5 pat / 5 prosth | Abutment loosening | 2 i / 2 pat / 2 prosth |
| Reactivation of clip | 12 i / 4 pat / 4 prosth | Abutment fracture | 1 i / 1 pat / 1 prosth |
| | | Prosthesis screw loosening | - |
| Foreseeable complications | | Prosthesis debounding | 4i / 3 pat / 3 prosth |
| Change of attachment | 33 i / 19 pat / 19 prosth | Major ceramic veneer fracture | 10 i / 5 pat / 6 prosth |
| Change of clip | 12 i / 3 pat / 3 prosth | Minor ceramic veneer fracture | 15 i / 10 pat / 12 prosth |
| Need for overdenture relining | 48i / 21 pat / 21 prosth | | |
| | | Prosthesis remake | 13i /8 pat / 9 proth |
| Unforeseeable complications | | | |
| Lack of stability (rotation) | 8 i / 4 pat / 4 prosth | | |
| Magnet wear | 2 i / 1 pat / 1 prosth | | |
| Fracture of extension bar | 4 i / 1 pat / 1 prosth | | |
| Tooth fracture on prosthesis | 3 i / 2 pat / 2 prosth | | |
| Prosthesis fracture and repair | 12 i / 5 pat / 5 prosth | | |
| Prosthesis fracture and remake | 2 i / 1 pat / 1 prosth | | |
| Opposing prosthesis fracture | 2 prosth | | |

Table 5 Evaluation of risk-factors.

| | | Complication | | |
|---|---|---|---|---|
| Unit | Factor | No | Yes | Chi-square test |
| Patient | Removable prosthesis | 17 | 33 (66.0 %) | $p < 0.05$ |
| | Fixed prosthesis | 146 | 19 (11.5 %) | |
| Fixed | Anterior rehabilitations | 25 | 0 (0 %) | $p < 0.05$ |
| Prosthesis | Posterior rehabilitations | 194 | 24 (11.0 %) | |
| Fixed | Cemented | 189 | 22 (10.4 %) | NS |
| Prosthesis | Screw-retained | 32 | 2 (5.9 %) | |
| Fixed | With extension | 12 | 5 (29.4 %) | $p < 0.05$ |
| Prosthesis | Without extension | 210 | 18 (7.9 %) | |
| Removable | Ball-anchored | 9 | 31 (77.5 %) | $p < 0.05$ |
| Prosthesis | Bar-anchored | 8 | 6 (42.9 %) | |
| Patient | Bruxer with FPD | 15 | 3 (16.7 %) | NS |
| | No bruxer with FPD | 131 | 16 (10.9 %) | |
| Patient | Bruxer with OD | 2 | 6 (75.0 %) | NS |
| | No bruxer with OD | 15 | 27 (62.8 %) | |

The following was investigated : fixation type (fixed vs. removable), localization (anterior vs. posterior), retention mode (cemented vs. screw-retained), presence of an extension cantilever, bar-retained vs. ball-retained overdentures, bruxism in edentulous and partially edentulous patients.

Patient was the unit when bruxism and rehabilitation type was considered. NS = not significant

Table 6 Cumulative percentage of complication-free prosthetic function for the fixed prostheses group over 8 years.

| Time interval | Protheses at risk | Drop out | Nb of prostheses with complication | Complication-free prostheses on interval | Cumulative complication-free prostheses rate |
|---|---|---|---|---|---|
| 0-1 y | 265 | 16 | 11 | 95.85% | 95.85% |
| 1-2 y | 249 | 1 | 4 | 98.39% | 94.31% |
| 2-3 y | 248 | 1 | 2 | 99.19% | 93.55% |
| 3-4 y | 215 | 0 | 4 | 98.14% | 91.81% |
| 4-5 y | 119 | 2 | 1 | 99.16% | 91.08% |
| 5-6 y | 72 | 0 | 2 | 97.22% | 88.51% |
| 6-7 y | 41 | 0 | 0 | 100% | 88.51% |
| 7-8 y | 27 | 0 | 0 | 100% | 88.51% |

Table 7a Cumulative percentage of event-free prosthetic function for the removable prostheses group over 8 years, When all events were considered.

| Time interval | Prostheses at risk | Drop out | Nb of prostheses with event | Event-free prostheses on interval | Cumulative event-free prostheses rate |
|---|---|---|---|---|---|
| 0-1 y | 55 | 3 | 13 | 76.36% | 76.36% |
| 1-2 y | 51 | 0 | 9 | 82.35% | 62.88% |
| 2-3 y | 51 | 1 | 13 | 74.51% | 46.85% |
| 3-4 y | 48 | 0 | 8 | 83.33% | 39.04% |
| 4-5 y | 25 | 0 | 5 | 80.00% | 31.23% |
| 5-6 y | 15 | 0 | 5 | 66.67% | 20.82% |
| 6-7 y | 12 | 0 | 2 | 83.33% | 17.35% |
| 7-8 y | 12 | 0 | 5 | 58.33% | 10.12% |

Table 7b Cumulative percentage of event-free prosthetic function for the removable prostheses group over 8 years, When the unforeseeable events only were considered.

| Time interval | Prostheses at risk | Drop out | Nb of prostheses with unforeseeable event | Unforeseeable event-free prostheses on interval | Cumulative unforeseeable event-free prostheses rate |
|---|---|---|---|---|---|
| 0-1 y | 55 | 3 | 8 | 85.45% | 85.45% |
| 1-2 y | 51 | 0 | 1 | 98.04% | 83.77% |
| 2-3 y | 51 | 1 | 3 | 94.12% | 78.84% |
| 3-4 y | 48 | 0 | 1 | 97.92% | 77.20% |
| 4-5 y | 25 | 0 | 0 | 100% | 77.20% |
| 5-6 y | 15 | 0 | 0 | 100% | 77.20% |
| 6-7 y | 12 | 0 | 0 | 100% | 77.20% |
| 7-8 y | 12 | 0 | 0 | 100% | 77.20% |

Table 8

Comparison between the fixed and the removable groups when the unforeseeable events only Were considered for the removable group.

| | for FPDs | for ODs with unforeseeable events only |
|---|---|---|
| Cumulative event-free prosthesis rate | 88.51% | 77.20% |
| 1-year incident-free rate | 95.6% | 84.6% |
| 2-year incident-free rate | 93.9% | 82.4% |
| 3-year incident-free rate | 95.1% | 76.0% |
| Rate of incident-free over 8 years | 90.20% | 74.0% |
| Nb of incidents / prosthesis | 0.10 | 0.27 |
| Rate of prosthesis remake | 3.7% | 2.0% |

Table 9 Cumulative percentage of complication-free prosthetic rehabilitation for the fixed prostheses group over 8 years when all biologic. (failures and peri-implantitis) and prosthetic events were taken into consideration.

| Time interval | Protheses at risk | Drop out | Nb of prostheses with complication (biologic and prosthetic) | Complication-free prostheses on interval (biologic and prosthetic) | Cumulative complication free prostheses rate (biologic and prosthetic) |
|---|---|---|---|---|---|
| 0-1 y | 265 | 16 | 14 | 94.72% | 94.72% |
| 1-2 y | 249 | 0 | 4 | 98.39% | 93.20% |
| 2-3 y | 248 | 1 | 3 | 98.79% | 92.07% |
| 3-4 y | 215 | 0 | 4 | 98.14% | 90.36% |
| 4-5 y | 119 | 2 | 2 | 98.32% | 88.40% |
| 5-6 y | 72 | 0 | 1 | 98.61% | 87.61% |
| 6-7 y | 41 | 0 | 0 | 100% | 87.61% |
| 7-8 y | 27 | 0 | 0 | 100% | 87.61% |

Table 10 Cumulative percentage of complication-free prosthetic rehabilitation for the removable prostheses group over 8 years. When all biologic (failures and peri-implantitis) and prosthetic events were taken into consideration.

| Time interval | Prostheses at risk | Drop out | Nb of prostheses with event (biologic and prosthetic) | Event-free prostheses on interval (biologic and prosthetic) | Cumulative event-free prostheses rate (biologic and prosthetic) |
|---|---|---|---|---|---|
| 0-1 y | 55 | 3 | 16 | 70.91% | 70.91% |
| 1-2 y | 51 | 0 | 10 | 80.39% | 57.01% |
| 2-3 y | 51 | 1 | 13 | 74.51% | 42.48% |
| 3-4 y | 48 | 0 | 8 | 83.33% | 35.39% |
| 4-5 y | 25 | 0 | 5 | 80.00% | 28.32% |
| 5-6 y | 15 | 0 | 5 | 66.67% | 18.88% |
| 6-7 y | 12 | 0 | 2 | 83.33% | 15.73% |
| 7-8 y | 12 | 0 | 5 | 58.33% | 9.18% |