# Medium- and Long-Term Complications in Full-Arch Rehabilitations Supported by Upright and Tilted Implants

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## ABSTRACT

*Purpose:* The purpose of this retrospective investigation was to present the incidence of biological and technical complications in patients treated with implant-supported, immediately loaded full-arch restorations.

*Materials and Methods:* Clinical data of all patients treated with full-arch, immediately loaded rehabilitations supported by a combination of upright and tilted implants were screened. Data on both technical and biological complications (such as peri-implant mucositis and peri-implantitis) and their onset and frequency of occurrence were recorded and analyzed.

*Results:* The clinical records of 86 patients (95 prosthetic rehabilitations) were included in this study. There were 61 mandibular rehabilitations and 34 maxillary ones, all of them immediately loaded within 8 to 48 hours of the surgical intervention. The follow-up time varied from 16.3 to 112 months of function (mean 65.36 months). The most common biological complications were hygiene-related ($n = 81$; 30.2% of patients displayed peri-implant mucositis and 10.4% peri-implantitis). Among all prosthetic complications, the detachment of an element of the definitive prosthesis was the most frequent event ($n = 20$; 23.2% of patients). The total number of prosthetic complications was 42. Most complications were reversible and did not affect the overall implant/prosthesis survival rate.

*Conclusions:* The occurrence in well-maintained patients of technical and biological complications in full-arch rehabilitations supported by a combination of tilted and upright implants in the medium to long term is lower than previously reported by the pertinent literature. Further studies are needed to confirm this result.

KEY WORDS: All-on-Four, complication, fracture, peri-implantitis

## INTRODUCTION

Full-arch implant-supported rehabilitations are widely considered a viable treatment option, with high success and survival rates for both implants and prostheses, even in the medium and long term.[1–4]

One of the most common full-arch rehabilitations is a fixed prosthesis supported by a variable number of implants, usually four to six, placed in the median portion of the jaws. This kind of prosthesis can be made of a milled metal bar screwed directly onto implant abutments and a resin portion for the replacement of teeth and mucosal tissues.[5,6]

While implant success has been widely investigated in the scientific literature and has been defined as the absence of infectious complications affecting peri-implant soft and hard tissues and the absence of more than 2 mm of peri-implant bone loss,[7,8] there is little information in the literature about prosthetic complications related to fixed implant-supported restorations.[9]

Biological complications affect soft and hard tissues surrounding implants. They can be caused by infection of soft tissues, which, in a secondary phase, can involve marginal bone, causing resorption and further spread of the infection. A strict maintenance protocol could limit the occurrence of infective complications,[10] while

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accurate planning of the prosthetic rehabilitation could avoid occlusal overload, preventing most occlusion-related prosthetic complications.

A recent systematic review reported data about prosthetic and biological complications related to full-arch rehabilitations.[9] Technical complications include screw loosening/fracture, veneering material chipping or fracture, need for replacement of resin tooth, framework fracture, loss of screw access filling material, fracture of the opposing restoration, and others.[9] The most frequent causes of failure are linked to characteristics of the material, prosthetic design issues, patient characteristics, or laboratory errors.[11]

Even though the literature reports a high prevalence of technical and biological complications over 5-year and 10-year follow-up periods, there is a lack of data about complications in well-maintained cohorts of patients.[9,12,13]

The aim of this retrospective investigation was to evaluate the incidence of biological and prosthetic complications occurring in patients treated with full-arch implant-supported prostheses supported by axially placed and tilted implants.

## MATERIALS AND METHODS

The patients included in this retrospective investigation were treated following the principles established in the Helsinki Declaration as modified in 2000.[14] The research project was approved by the review board of the IRCCS Istituto Ortopedico Galeazzi in Milan, Italy (RC 2012 No. 4.73). Patients were all treated in the dental clinic of the IRCCS Istituto Ortopedico Galeazzi in Milan, Italy. All surgeries were performed by a team having more than 10 years of experience in implant surgery. Patients were recruited and treated in the period between 2003 and 2012.

Clinical records of patients consecutively treated with full-arch rehabilitations (both maxillary and mandibular) supported by a combination of two straight and two tilted implants, following the All-on-Four® concept (Nobel Biocare, Zurich, Switzerland),[15,16] were selected. All included patients were well maintained and were recalled every 6 months for the first 2 years and then yearly.

Patient inclusion criteria were the following:

- Clear indication of treatment characteristics and timing (date of surgery, date of prosthesis placement);
- Presence of information about the occurrence of biological or technical complications (date of occurrence, description of complication).

All records with inadequate data or insufficient information about the occurrence of any complications were excluded.

The following data were retrieved from clinical records:

- Demographic characteristics of patients (age, gender);
- Smoking habits;
- Opposing dentition (natural teeth, removable denture, fixed implant-supported prostheses);
- Characteristics of the rehabilitation (maxillary or mandibular);
- Occurrence of complications by date and type of complication.

The following types of complications were recorded:

- Peri-implant mucositis: peri-implant mucosa redness and swelling in absence of alveolar bone loss, as described elsewhere[10];
- Peri-implantitis: presence of peri-implant soft tissue inflammation with evidence of persistent peri-implant bone loss, confirmed through the use of periapical radiographs;
- Implant loss;
- Difficulties in maintaining oral hygiene around the prosthetic abutments (inadequate plaque control, reported difficulties in using oral hygiene devices);
- Detachment of one or more elements of the definitive or provisional prosthesis;
- Fracture of the definitive or provisional prosthesis, as well as fracture of the suprastructure or the resin components;
- Other complications (e.g., screw loosening or screw fracture).

These complications were grouped into biological complications (peri-implant mucositis, peri-implantitis, implant loss and difficulties in hygiene maintenance) and technical ones (detachments and fractures).

Data about date of occurrence and recurrence of specific complications were recorded in an ad hoc prepared database. Analysis of pooled frequencies of occurrence were calculated, and Pearson's correlation test was used to evaluate the correlation among various complications and other parameters such as age, gender, and type of opposing denture.

**TABLE 1 Demographic Data**

| | |
|---|---|
| Number of patients (M/F) | 86 (40/46) |
| Age (years), mean ± SD (range) | 58.4 ± 9.9 (40.8–84.7) |
| Number of maxillary cases (M/F) | 16/18 |
| Number of mandibular cases (M/F) | 28/33 |
| Smokers (% of patients) | 44% |
| Number of cigarettes daily, mean ± SD (range) | 11.4 ± 9.8 (2–40) |

## RESULTS

Clinical records of 86 patients (95 prosthetic rehabilitations), selected from those attending the dental clinic of the IRCCS Istituto Ortopedico Galeazzi in Milan, Italy, were included in this study. Demographic data of the patients are presented in Table 1. There were 61 mandibular rehabilitations (28 in males and 33 in females) and 34 maxillary ones (16 in males and 18 in females), all of them immediately loaded within 8 to 48 hours of surgical intervention. The follow-up time varied from 16.3 to 112 months (mean 66.4 ± 23.0 months) of function.

Data regarding the occurrence of complications are summarized in Table 2. The most frequent complications were oral hygiene problems (53.5% of patients) and (as a consequence) peri-implant mucositis (30.2% of patients). Among all technical and prosthetic complications, the detachment of an element of the definitive prosthesis was the most frequent occurrence (23.2% of patients) (Figure 1). Fracture of the metal framework occurred in 7.0% of patients (Figure 2). In 10.4% of patients, peri-implantitis affected one or more implants.

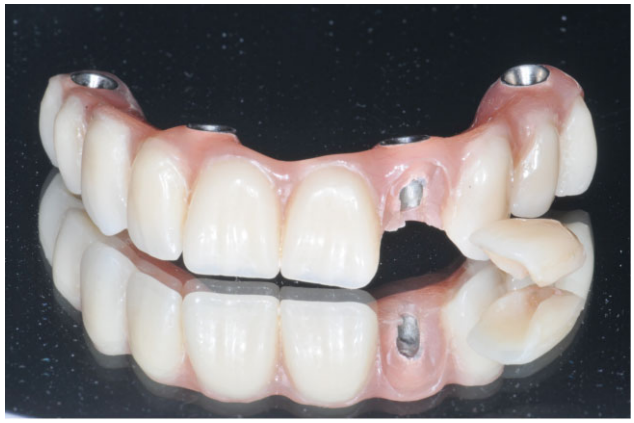

**Figure 1** Detachment of veneer in the definitive prosthesis.

In Table 3, data about the time a complication was first reported are presented. There was a certain heterogeneity in the times of first occurrence. Hygiene problems were the earliest-occurring complications, while fractures and detachments of the definitive prosthesis were the latest-occurring ones. No correlation was found among the incidence of complications (number of complications and onset time), age, gender, and type of opposing dentition.

## DISCUSSION

This retrospective study investigated the occurrence of complications in patients treated with full-arch, implant-supported, immediately loaded rehabilitations following the All-on-Four protocol.

The scientific literature has shown that rehabilitations supported by a combination of upright and tilted

**TABLE 2 Number and Prevalence of Complications**

| | Mandibular Cases | | Maxillary Cases | | Total | | |
|---|---|---|---|---|---|---|---|
| | *n* | % of Total | *n* | % of Total | *n* | % of Total | % of Patients |
| Mucositis | 21 | 21.7 | 5 | 11.1 | 26 | 18.3 | 30.2 |
| Peri-implantitis | 7 | 7.2 | 2 | 4.4 | 9 | 6.3 | 10.4 |
| Detachment (definitive) | 13 | 13.4 | 7 | 15.6 | 20 | 14.1 | 23.2 |
| Detachment (provisional) | 3 | 3.1 | 6 | 13.3 | 9 | 6.3 | 10.5 |
| Fracture (definitive) | 4 | 4.1 | 2 | 4.4 | 6 | 4.2 | 7.0 |
| Fracture (provisional) | 3 | 3.1 | 4 | 8.9 | 7 | 4.9 | 8.1 |
| Implant loss | 0 | 0.0 | 2 | 4.4 | 2 | 1.4 | 2.3 |
| Hygienic problem | 35 | 36.1 | 11 | 24.4 | 46 | 32.4 | 53.5 |
| Others | 11 | 11.3 | 6 | 13.3 | 17 | 12.0 | 19.8 |
| Total | 97 | | 45 | | 142 | | |

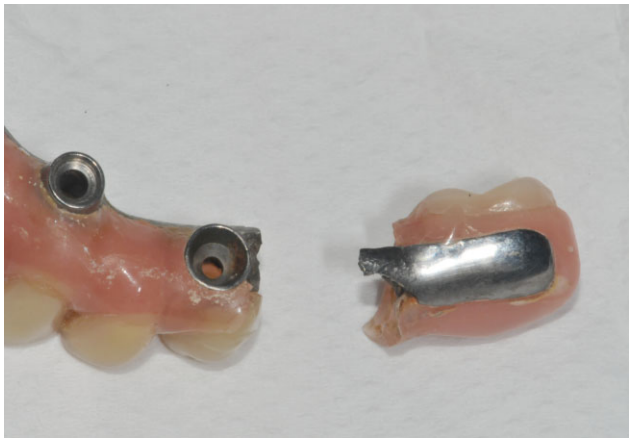

**Figure 2** Fracture of the metal framework.

implants with distal cantilevers can have a high success and survival rate (both implants and prostheses) in the medium term.[15–23] In fact, the protocol used in this study aims at the reduction of cantilever extensions via a more distal position of the posterior abutments, which can be achieved by tilting the distal implant.[15,16] Moreover, a low number of implants allows easier cleaning of the abutment, improving plaque control and reducing the risk of plaque-related biological complications.[19] All these characteristics may contribute to an overall reduction of the risk of complications, both technical and biological.

In the present study, biological and technical complications never caused the failure of the entire rehabilitation. In fact, most complications, with the exception of peri-implantitis and implant loss, could be solved.

Biological complications, such as peri-implant mucositis and peri-implantitis, have been described in the literature as being among the most frequent causes of late implant failure due to bone loss following inflammation of peri-implant soft and hard tissues.[24] A recent review of the literature reported that peri-implant mucositis could be diagnosed in 80% of implants and 50% of patients, while peri-implantitis could be found in more than 50% of patients and more than 40% of implants in the medium term.[25] In the present study, the reported prevalence of peri-implant mucositis and peri-implantitis was lower than has been presented previously. In fact, as stated in one previously published article, patients who undergo a strict hygiene protocol may have a reduced incidence of such biological complications due to adequate plaque control.[10] Moreover, it has been demonstrated that when initial lesions are diagnosed in time, simple treatment options, such as plaque removal and antiseptic rinsing, can lead to complete resolution of these lesions, avoiding the occurrence of more severe peri-implantitis.[26] However, it has to be stated that the prevalence of peri-implant mucositis and peri-implantitis presently reported should be evaluated carefully because of the relatively short follow-up period and the small sample size.

As regards technical and mechanical complications, a review performed by Salvi and Bragger in 2009 stated that presence of cantilevers, high crown/implant ratio and greater reconstruction length were associated with technical complications.[27] In particular, the presence of cantilevers has been recognized as an important risk factor, especially in comparison with prostheses without unsupported extensions.[28] However, most authors report that such technical and mechanical complications do not affect the survival rate of either implants

**TABLE 3 Mean Advent of Complications in Months**

| | Mandibular Cases | | Maxillary Cases | | Total | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Mucositis | 25.6 | 17.3 | 18 | 21 | 24.1 | 17.8 |
| Peri-implantitis | 33.3 | 24.6 | 30 | 24 | 32.5 | 23 |
| Detachment (definitive) | 20.3 | 11.1 | 20 | 14 | 20.3 | 11.8 |
| Detachment (provisional) | 5.4 | 4.7 | 3.6 | 1.2 | 4.22 | 2.66 |
| Fracture (definitive) | 52.1 | 26.4 | 23 | 8.8 | 42.3 | 25.7 |
| Fracture (provisional) | 5.2 | 3.0 | 5.9 | 4.1 | 5.6 | 3.41 |
| Implant loss | 0 | 0 | 1.8 | 2.5 | 1.8 | 2.45 |
| Hygienic problem | 13.0 | 13.4 | 16 | 11 | 13.7 | 12.9 |
| Others | 17.2 | 29.0 | 8.9 | 8.3 | 14.3 | 23.7 |

or prostheses.[27] Also, in the present report, none of the patients with one technical complication experienced a complete failure of the rehabilitation.

The occurrence of this kind of complication was also studied for rehabilitations like the one described in this retrospective report. Both Agliardi and colleagues[21] and Francetti and colleagues,[19] in their prospective studies on different cohorts of patients, reported that fracture of the acrylic resin was a frequent occurrence for this kind of rehabilitation.

As described in the literature, most fractures of the resin or veneer detachment occurred in patients with short face morphology or following the change from soft to hard diet.[17,19,21] The cause of these complications should be sought in parafunctional habits. However, it has been demonstrated that patients wearing implant-supported prostheses positioned following the All-on-Four protocol do not show modifications in neuromuscular equilibrium as compared with patients with natural dentition or wearing one fixed prosthesis and one removable one.[29] The same was also observed in studies evaluating other types of implant-supported rehabilitations.[30]

Interestingly, the present investigation did not report any fracture of the framework or the abutments, suggesting that these types of complications, which can be solved only through complete substitution of the prosthesis, can be avoided using an adequate prosthetic protocol. These results were comparable with those presented in a study by Ortorp and Jemt with a shorter follow-up period, in which implants did not show any fracture of the metal framework.[31] Interestingly, evaluating the same cohort of patients, Ortorp and Jemt reported no fractures after 3 years,[32] and one fracture occurred after 10 years.[33] It has to be considered that the All-on-Four protocol aims to shorten the distal cantilevers, reducing the mechanical stress to the framework and implant abutments. In fact, a recent systematic review dealing with this particular protocol reported only one fracture of the metal framework[17] (described by Landazuri-Del Barrio and colleagues[34]). It has to be considered that other authors report an estimated technical complication rate of 4.9% after 5 years and 9.8% after 10 years for full-arch rehabilitations not following the All-on-Four protocol.[9] Studies using finite element analysis to investigate the effects of tilting implants and shortening the distal cantilevers on distribution of occlusal stresses through the metal framework and surrounding bone have demonstrated that the reduction of unsupported extensions can have a beneficial effect on the overall stress borne by the prosthetic structure.[35–38]

It can be hypothesized that efforts to reduce stresses to the framework through tilting the implants can be a protective factor and lower the risk of framework damage. As an adjunct, tilting implants did not affect bone resorption rates, preventing implant loss.[9,39]

In conclusion, the present retrospective study found that the occurrence of technical and biological complications in full-arch rehabilitations supported by a combination of tilted and upright implants was lower than the incidences presented in the pertinent literature. Furthermore, most complications were reversible and did not affect the survival rates of implants and prostheses in well-maintained patients.

More studies with longer follow-up are needed in order to achieve a better understanding of risk factors for prosthetic and biological complications, validating maintenance and recall protocols that can prevent such occurrences.

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