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Clinical and radiographic assessment of implant-supported rehabilitation of partial and complete edentulism: a 2 to 8 years clinical follow-up

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Abstract. – OBJECTIVE: The aim of this study was to find out the rates of survival and success of implant rehabilitation, and the influence of some risk indicators on the medium- and long-term prognosis.

PATIENTS AND METHODS: Of the 102 patients eligible for this study rehabilitated with dental implants during the years 2009-2015, 75 patients with 156 implants of different implant systems placed and loaded by the same team were recalled. For each subject, pocket-probing depth, bleeding on probing, plaque buildup, mobility of the fixtures, and the presence/absence of prosthetic complications were recorded. Radiographic evaluation was based on the analysis of bone levels around the fixtures, as shown by intraoral radiographs.

RESULTS: The average follow-up was 4.4 years, ranging from 1.5 to 7.8 years. One hundred and fifty-four of the implants survived, while two implants failed; 98.8% of the prostheses survived, while 75.9% were successful. Success was achieved in 90.4% of implants and in 80% of patients. The sample showed average radiographic bone resorption of 1.09 mm. The average pocket probing depth was 2.79 mm. Bleeding on probing was found in 18% of all sites, and 59.6% of implants showed bleeding on probing in at least one site. Mucositis was found in 90% of patients, and peri-implantitis was found in 16% of patients.

CONCLUSIONS: The rates of success and survival showed the reliability of implant therapy. Plaque accumulation, smoking and upper jaw location, seem to increase the risk of failure of implant-supported rehabilitation.

Key Words
Implant survival, implant succes, risk factors, implant failure, dental implant, implant supported rehabilitation

Introduction

Implant-prosthetic rehabilitation represents nowadays a highly predictable therapy for partially and completely edentulous patients. In recent years, reported survival and clinical success rates have kept improving[1-5]. Biological aspects of osseointegration have been investigated, resulting in extremely high rates of early biological success. However, there is still concern about mechanical or technical complications and about late biological complications. Several factors have been suggested to be detrimental for long-term prognosis of implant rehabilitations, including jaw location, local anatomy, implant dimensions, bone density at the surgical site, bone augmentation procedures[6-10] and patient-related factors such as smoking and a history of periodontal disease [11-16]. Implant therapy complications can be summarized as biological or prosthetic. Early biological complications involve the osseointegration process, and can cause fast loss of the fixture, while late complications include peri-implant infective diseases like mucositis or peri-implantitis.

Prosthetic complications are divided into mechanical (mechanical failure of industrial elements of the rehabilitation) or technical ones (lab-made element failure). Overdentures (OVDs) on implants show a high rate of complications such as loss of retention, clip/attachment fracture, relining needs and other problems that must be treated by clinicians[17,18]. A common complication of implant-supported restorations such as single crowns (SCs) or fixed partial dentures (FPDs) is fracture or chipping of crown restoration, or screw loosening. Screw retention and cement retention do not seem to be risk factors for the prognosis of rehabilita-

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tion[19-21]. While implant survival is regarded as the presence of the fixture in the oral cavity, evaluation of implant success needs criteria to be defined. Albrektsson criteria[22] are still heavily contemplated. However, they do not consider other conditions that could jeopardize implant prognosis, like peri-implant probing depth. Prosthetic survival is defined also as the presence of the restoration without modification during an observation period[23], while success could be seen as an absence of complications.

The aim of this retrospective study is to find out the rates of survival and success of implants placed in patients treated at the Oral Surgery and Implantology Unit, Agostino Gemelli Hospital, Catholic University of the Sacred Heart, Rome, and the influence of some risk indicators on the medium- and long-term prognosis.

Patients and Methods

Patients

Seventy-five patients fulfilling our recruitment criteria were analyzed. Exclusion criteria included incomplete medical records, severe kidney and liver diseases, immunodeficiency states, history of radiotherapy in the head-neck region, poorly controlled diabetes, untreated or mistreated periodontal disease mellitus, oral lesions in the surgery site region, discontinued follow-up, and refusal to enroll in this study. All patients provided informed, written consent to scientific use of their data according to the World Medical Association's Declaration of Helsinki. A total of 156 implants from several producers were placed (Table I). Implants examined were placed with two-stage surgery, both in sites with no need for bone augmentation and those with a need for bone augmentation. After 3-4 months of osseointegration, the prosthetic phase was performed; completion of the prosthetic phase was considered the baseline (B). All patients were instructed on how to maintain appropriate oral hygiene around the implants and remaining teeth, and they were enrolled in a professional recall for oral hygiene every 4 months.

Table I. Frequency of implant type.

Implant producer	Frequency	Percentage
Neoss Ltd., Harrogate, UK	66	42.3
BIOMET 3i Implant Innovations, Palm Beach Gardens, FL, USA	57	36.5
Straumann AG, Basilea, Switzerland	15	9.6
Nobel Biocare AB, Göteborg, Sweden	12	7.7
Prodent Italia Srl, Milano, Italy	6	3.9

All patients enrolled in the study were treated exclusively by two trained clinicians (A.D., P.F.M.) who performed, respectively, the surgical and prosthetic phases of the implant rehabilitation. All prosthetic restorations were made by two experienced dental technicians. The first dental technician performed all FPDs and SCs; the second dental technician performed all OVDs and Toronto Bridges (TBs). Overall, 87 implant-supported restorations were performed. All FPDs and SCs were gold-porcelain crowns. OVDs were made totally of resin, while TBs were resin with a metal framework. All FPDs and SCs were cemented with oxyphosphate cement[24]. Implant and prosthetic conditions were evaluated by clinical examination, and juxta-gingival radiographs were carried out using the Rinn system to control distortion (XCP Instruments, Rinn Corporation, Elgin, IL, USA).

All implant sizes determined by radiography were compared with actual sizes to rule out the possibility of non-parallel projection. The following parameters were evaluated:

Radiographic assessment of peri-implant marginal bone level (MBL) mesial and distal to each implant. Bone loss was determined by comparing the distance between the most coronal levels of mesial and distal bone to implant contact in the radiographs taken at the time of prosthetic loading and on examination. ImageJ software (National Institute of Health, Bethesda, MD, USA) was used for the computerized analysis of these distances.

- Peri-implant pocket probing depth (PPD) measured with a calibrated plastic probe at six sites around every implant (mesio-vestibular, vestibular, disto-vestibular, mesio-lingual, lingual, disto-lingual).
- Bleeding on probing (BoP) measured with a dichotomic index [25] at four peri-implant sites (mesial, vestibular, distal, lingual).
- Plaque presence, assessed visually and by the means of a plastic probe, at four peri-implant sites (mesial, vestibular, distal, lingual).
- Implant mobility, assessed with two instrument handles.
- Presence of prosthetic complications such as loss of retention, veneer or framework fracture, or loosening of abutment connection.

Table II. Frequency of implant location and type of prosthesis.

Implant producer	Frequency	Percentage
Maxilla implants	66	42.3
Mandible implants	90	57.7
Anterior implants	47	30.1
Posterior implants	109	69.9
Fixed partial dentures (FPDs)	27 (69 implants)	31.1
Single crowns (SCs)	45 (45 implants)	51.7
Overdentures (OVDs)	12 (24 implants)	13.8
Toronto bridge (TBs)	3 (18 implants)	3.4

The success of implant rehabilitation was assessed according to the criteria used by Ong et al[26]. Implant success criteria were: no mobility, no suppuration, no symptoms (like pain or paresthesia), no peri-implant radiolucency, no marginal bone loss greater than 1 mm in the first year plus 0.2 mm per year in subsequent years, and no PPD greater than 5 mm. Prosthetic restorations were considered a success when they had no history of complications, and were sustained by successful implants. Implants were considered as surviving if they were *in situ* and asymptomatic during inspection. Clinical symptoms or mobility would have indicated mandatory implant removal. Prosthetic restorations were considered as surviving if they were still functional. Only patients who showed success in all implants were considered successful, while rehabilitation success implied total implant and prosthesis success, that is rehabilitation that had never needed any corrective intervention.

Statistical Analysis

Statistical analysis was done with Stata statistical software (Release 13; StataCorp LP, College Station, TX, USA). Descriptive analysis was conducted to report the characteristics of implant location, type of prosthesis and periodontal parameters. Values were expressed as mean and standard deviations for continuous variables, or absolute frequency and percentages for categorical variables. Comparison of continuous variables between groups was evaluated by *t*-test, and comparison of categorical variables was appraised by Z-test to determine the difference between two proportions, or the Fisher test as appropriate. p-value < 0.05 was considered significant.

Results

Of a total sample of 102 patients eligible for this study rehabilitated with dental implants from 2009 to 2015, 75 patients were analyzed. Two patients had died, and 25 patients were not available or did not want to participate; 33% (25 patients) were males and 67% (50 patients) females. The mean age was 66 years, and 16% (12 patients) of the patients were smokers (up to 10 cigarettes per day). One hundred and fifty-six dental implants were analyzed; frequency of implant location and type of prosthesis are reported in Table II. Follow-up after prosthetic rehabilitation ranged from 1.5 to 7.8 years (mean 4.4 years).

Of all sites evaluated, 14.1% showed plaque buildup, while 18% were positive for BoP. Overall

Table III. Periodontal parameters.

	Overall	Mesial sites	Distal sites	*T-test p-value*
MBL loss	1.09 mm (SD 0.65)	1.05 mm (SD 0.69)	1.13 mm (SD 0.62)	$p = 0.24$
	Overall	**Sites with PPD > 5 mm**		
PPD	2.79 mm (SD 0.82)	18 (2%)		
	Overall	**Implant with BoP+***		
BoP+	111 (18%)	93 (59.6%)		
	Sites with plaque	**Patients with plaque***		
Plaque	87 (14.1%)	30 (40%)		

**in at least one site around the implant.*

Table IV. Influence of risk indicators on periodontal parameters.

	PPD smokers	PPD non-smokers	*T-test p-value*
Smoking	2.86 mm (SD 0.78)	2.44 mm (SD 0.93)	$p = 0.0287$
	MBL loss smokers 1.25 mm (SD 0.38)	MBL loss non-smokers 1.04 mm (SD 1.04)	$p = 0.0263$
	PPD with plaque	**PPD without plaque**	***T-test p-value***
Plaque	2.84 mm (SD 1.17)	2.63 mm (SD 0.95)	$p = 0.1252$
	MBL loss smokers 1.25 mm (SD 0.38)	MBL loss non-smokers 1.04 mm (SD 1.04)	$p = 0.0263$
	PPD around I. > 10.7 mm	**PPD around I. < 10.7 mm**	
Implant length	2.79 mm (DS 0.70)	2.67 mm (DS 0.91)	$p = 0.3669$
	MBL loss around I. >10.7 mm 1.13 mm (DS 0.65)	MBL loss around I. < 10.7 mm 1.03 mm (DS 0.67)	$p = 0.1861$
	PPD around I. > 4.3 mm	**PPD around I. < 4.3 mm**	***T-test p-value***
Implant diameter	2.82 mm (SD 0.83)	2.70 mm (SD 0.82)	$p = 0.2442$
	MBL loss around I. > 4.3 mm 1.10 mm (SD 0.61)	MBL loss around I. < 4.3 mm 1.04 mm (SD 0.77)	$p = 0.4836$
	PPD around I. in maxilla	**PPD around I. in mandible**	***T-test p-value***
Implant position	2.73 mm (SD 0.78)	2.60 mm (SD 0.79)	$p = 0.3132$
	MBL loss around I. in maxilla 1.06 mm (SD 0.77)	MBL loss around I. in mandible 1.12 mm (SD 0.55)	$p = 0.4245$

mean PPD for all sites was 2.79 mm (SD 0.82), and the mean MBL loss was 1.09 mm (SD 0.65) (Table III).

Considering peri-implantitis as radiographical evidence of non-physiological bone resorption (more than 1 mm in the first year after loading, and 0.2 mm per year for every subsequent year), and a positive BoP[24-25], 9.6% of implants and 16% of patients showed signs of pathology.

Among smokers, 81.9% of implants and 75% of patients showed clinical success. Non-smokers had 92.8% implant success, and 85.7% of patients had only successful implants. Mean PPD and MBL loss among smoking patients were, respectively, 2.86 mm (SD 0.78) and 1.25 mm (SD 0.65) versus 2.44 mm (SD 0.93) and 1.04 mm (SD 1.04) in non-smokers; these differences were found to be statistically significant ($p = 0.0287$ and $p = 0.0263$, respectively).

Bone resorption was higher in the plaque sample: mean MBL loss was 1.20 mm (SD 0.61), while in the non-plaque group, mean MBL loss was 1.02 mm (SD 0.68). This difference is considered to be statistically significant ($p = 0.0134$).

The wider implant sample showed a PPD of 2.82 mm (SD 0.83) against 2.70 mm (SD 0.82) in the narrower sample ($p = 0.24$). According to our analysis criteria, mandibular implants showed a success rate of 92.8%, while the maxillary implant success rate was 79.2%. Bone augmentation procedures did not influence success or survival rates. All details regarding the influence of risk indicators on periodontal parameters and on therapy success are reported in Tables IV and V. Six prostheses (6.9%) had mechanical or technical complications (Table VI). One hundred and fifty-four (98.7%) of the implants original 156 were still functional in the oral cavity, and none of them caused pain, paresthesia or other symptoms. Two implants showed mobility or peri-implant radiolucency, and were removed. Success was achieved in 90.4% of implants and in 80% of patients; 98.8% of the prostheses survived, and 75.9% were successful. One prosthetic resto-

Table V. Influence of risk indicators on therapy success.

	Successful implants among smokers	Successful implants among non-smokers
Smoking	27 (81.8%)	114 (92.7%)
	Successful patients among smokers	**Successful patients among non-smokers**
	9 (75%)	54 (85.7%)
	Successful implants with plaque	**Successful implants without plaque**
Plaque	48 (76.2%)	84 (90.2%)
	Successful implants > 10.7 mm	**Successful implants < 10.7 mm**
Implant length	77 (83.3%)	57 (91.0%)
	Successful implants > 4.3 mm	**Successful implants < 4.3 mm**
Implant diameter	85 (83.3%)	49 (90.6%)
	Successful implants in maxilla	**Successful implants in mandible**
Implant position	57 (79.2%)	77 (92.8%)

ration (SC) was considered a failure because the SC failed with the implant. Survival, success, and pathology rates, are reported in Table VII.

Discussion

This retrospective study on the survival and success of dental implants and implant-supported rehabilitation in partially and totally edentulous patients was carried out with the aim of adding to the limited data available in the scientific literature. Although efforts were made to recall all living patients, a number of patients were unable or unwilling to attend. The high dropout rate of this study (27 of 102 patients, i.e., 26%) has to be kept in mind when interpreting the results. Implant survival rate and overall implant success rate following the adopted criteria were consistent with recent evidence[5,26], showing a good medium-term implant prognosis. However, the lack of standardized and internationally recognized success criteria makes it difficult to compare different studies in the current literature. Prosthetic survival rate was similar to those from the results of previous studies, while rehabilitation success (rehabilitation that had never needed any chairside or lab intervention on implant or prostheses) was consistent with current evidence, which states that one rehabilitation in four will need some kind of intervention in 5 years[17,27]. The incidence of surgical and prosthetic complications in this study was very low. This finding can be attributed both to the strict protocol used for surgical and prosthetic phases, and to the cumulative experience of the two clinicians. The most common complication in this sample was a biological one. Mucositis around implants, shown by BoP[28-31], was found in 90% of patients. This result is consistent with much other evidence[32-36]. The prevalence of peri-implantitis in the study sample is consistent with the results of previous studies[37-40]. Prosthetic complications revealed in this sample are consistent with the most common complications claimed by many authors: two cases of loss of retention in OVD connections, one case of fracture of the resin in a TB, two cases of fracture of the porcelain veneer in FPDs, and one case of abutment screw loosening in an SC rehabilitation[17,18].

Table VI. Prosthetic complications.

Complications	Frequency	Percentage
Ceramic veneer chipping (FPD, SC)	2	33.3
Loss of retention (overdenture – OVD)	2	33.3
Resin fracture (Toronto Bridge – TB)	1	16.7
Abutment screw loosening (single crown – SC)	1	16.7
Total	6	100.00

Total prosthetic complications: 6.89%.

Table VII. Survival, success and pathology rates.

	Implants survived	**Implants lost**
Survival	154 (98.7%)	2 (1.3)
	Prostheses survived 86 (98.8%)	**Prostheses lost** 1 (1.2%)
	Successful implants	**Unsuccessful implants**
Success	141 (90.4%)	15 (9.6%)
	Successful prostheses* 66 (75.9%)	**Unsuccessful prostheses** 21 (24.1%)
	Successful patients 60 (80%)	**Unsuccessful patients 15 (20%)**
	Implants	**Patients**
Peri-implantitis	15 (9.7%)	12 (16%)

**Successful prostheses associated with successful implants only.*

Several factors showed a possible detrimental role in implant prognosis. In the sample with plaque buildup around implants, there was more than double the number of sites with a PPD greater than 5 mm and with BoP compared to those for cleaner sites. These results are comparable with much other evidence[41-43]. Smoking was detrimental for implant prognosis. Frequency of BoP is directly proportional to the severity of disease around teeth and implants[44]. Marginal bone loss was significantly greater in the sample of smokers; they also showed significantly lower PPD results, perhaps due to the development of mucosal recessions. Smoking is considered by a great number of studies as the main risk factor for implant therapy[35,41,45-47]. Fixtures in the maxillary arch had a worse success rate than those in the mandibular arch, probably related to bone quality[48-50]. Implants in the upper jaw also had a statistically significantly smaller mean PPD than that for mandibular implants.

Conclusions

We showed that implant-prosthetic rehabilitation has high rates of survival and success, and represents nowadays a good treatment. Mucositis is the most common complication for implant patients. Risk indicators that seem to be detrimental to medium- and long-term prognosis are plaque buildup around implants, and cigarette smoking. Maxillary implants seem to show a less favorable prognosis than mandibular ones. The results of this study indicate that the use of implants is a predictable method for the treatment of partially or completely edentulous patients, if a proper clinical protocol is followed. The need for a strict recall program must also be emphasized.

Conflict of interest

The Authors declare that they have no conflict of interests.

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