Long-term clinical outcome of dental implants: A retrospective clinical study with a minimum follow-up between 9.5 and 17.7 years

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The aim of this retrospective case series was to evaluate the clinical and radiographic outcomes of the patients that underwent implant surgery in all indication classes, with a follow-up of at least 9 years. 121 healthy patients in need for oral rehabilitation with dental implants were included in this study. 196 implants (160 conical, 73 cylindric design implants) were inserted. The implant survival rate was the primary outcome. Intra- and postoperative complications were additional criteria for success. The mean follow-up of the patients was 12.29 years (SD 1.39). Mean age of the study population was 51.0 years (SD 12.7). The mean bone loss around implants after at least 9 years of loading was measured as 2.0 mm (SD 0.73 mm). Intra-operative complications were seen in 5 patients. Post-operative complications included: 5 mucositis,1 dehiscence, 2 screw loosening, 1 infection at site and 1 non-integrated implant. Two implants were lost in two patients. The overall implant survival rate was 99.1%. As a conclusion, oral rehabilitation with dental implant-supported prostheses can be accepted as a safe procedure with relevantly high survival rates of oral implants and successful aesthetic and functional outcomes.

The replacement of missing teeth with the use of endosseous, osseointegrated implants was introduced by Brånemark et al in the 1960's (1-4). Initially, titanium implants were used in edentulous patients to support fixed dental prostheses and to increase the quality of life of the patients in terms of chewing (2, 5). In the 1970's and 1980's, a variety of implant materials were clinically tested, such as aluminum oxide, titanium aluminum-vanadium alloy etc. In the mid-1980's Albrektsson et al. introduced the threaded solid screw-type pure titanium implant as an evolution in dentistry (2, 6). The next phase in implant therapy started in these mid-1980's when implant therapy expanded into partially edentulous patients. Dental implant based oral rehabilitation clinical outcome publications increased significantly by 1990's reporting various bone augmentation procedures such as, guided bone regeneration utilizing barrier membranes and sinus floor elevation (2-4, 7-10).

In our modern world, dental implant insertion for oral rehabilitation is considered as a routine, highly predictable and successful treatment modality with well documented clinical follow-up findings. Success is usually measured by evaluating the bone loss using standardized radiographs, gingival health, function, and patient comfort (5, 11). In general, accurate diagnosis and planning are crucial factors for implants to be placed in their ideal location (5).

Key words: dental implants; dental implant survival; implant diameter; long-term follow-up; marginal bone loss; peri-implantitis

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Several long-term clinical papers reporting on 10-year clinical outcomes with contemporary modern surface-modified implants reveal an implant survival rate of more than 95% (2). Publications on long-term outcomes of dental implant treatments usually focus on crestal bone loss (12, 13). In most of the cases, crestal bone loss during the implant's first year of function usually occurs as a result of bone remodeling as a reaction to surgery (13). In the following years, marginal bone loss usually a result of non-optimal surgery, prosthodontics, implant components, the immunologic response and/or other patient specific factors (13). Peri-implantitis is one of the major reasons for implant loss. Albrektsson et al. in 2012 reported 2.7% of dental implants are affected by peri-implantitis, when followed up for 10 years (12). Recently, controversial data on the long-term marginal bone loss and survival rates of implants placed in augmented vs. pristine bone have been reported (14-19).

Currently, the publications about dental implant success are usually clinical studies that were done in a university environment and by specialist surgeons on oral surgery/implantology. To optimize the results of dental implant based oral rehabilitation, there is still a lack of publications in the literature especially on long term results of dental clinics with implants inserted by general practitioner dentists for evaluating real world results from private dental clinics. The aim of this multicentric study was to evaluate the long-term outcomes of dental implants in all indication classes, considering implantations performed from April 2003 to May 2011 in the setting of five different private clinics.

MATERIALS AND METHODS

This multicentric retrospective case series study was carried out in private clinics that had agreement with University of Milano/IRCCS Orthopedic Institute Galeazzi and consisted of patients that had received oral rehabilitation with dental implants. All the patients were treated between 01.04.2003 and 16.05.2011. The study was compliant to the principles laid down in the Declaration of Helsinki on medical protocol and ethics. A signed informed consent form was obtained from all subjects for the medical and surgical procedure and for the use of data in the research. Institutional Review Board approval of the IRCCS Orthopedic Institute Galeazzi was obtained for retrospective studies on implant therapy, with number 2552377-L2058/RC 2019 ("Implant rehabilitation of the partially or totally edentulous patient: evaluation of techniques and materials to improve predictability and maintenance").

Patient selection

Medical records were collected retrospectively from Clinics' database of patients who underwent placement of dental implants with alumina sandblasted and acid-etched surface for oral rehabilitation with a minimum follow-up of 9 years.

The inclusion criteria were as follows:

- patients older than 18 years of age
- patients that received one or more dental implants for oral rehabilitation
- minimum 9 years of follow-up after implant insertion
- patients without any general medical contraindications for oral surgery procedures (American Society of Anaesthesiologists ASA-1 or ASA-2)
- ability to sign an informed consent form.

The subjects suffering from any major systemic illness (ASA 3-ASA 6) like immunocompromised patients, oncologic patients, patients with organ failures, coagulation disorders, pregnant patients, patients who had received radiotherapy/chemotherapy and patients with untreated active periodontal infection and/or active infection in the oral and maxillofacial region were excluded. Smoking habits, controlled diabetes, osteoporosis, bruxism, and minor systemic conditions were not considered as exclusion criteria.

Five different surgeons inserted the implants assessed in this study, according to the surgical recommendations of the manufacturer (Dental Tech S.r.l., Misinto (MB), Italy). The implants utilized in this study consisted of IMPLASSIC® FT3 (submerged, cylinder implants), IMPLASSIC® FT2 (short (6-7mm), submerged, cylinder implants, IMPLASSIC TR2 (transmucosal, cylinder implants), IMPLASSIC® TR2 (transmucosal, cylinder implants with wide prosthetic platform), IMPLOGIC® GII (submerged, conical implants), IMPLOGIC® AT

(submerged, conical implants, active thread in cases immediate implantation at post-extraction sites). All these implants listed above had a pure aluminum sandblasted-acid etched surface.

The preoperative evaluation of all the patients consisted of clinical and panoramic radiographic examinations of the implant sites (Fig. 1). Primary visit consisted of anamnesis for general health status with a detailed clinical intra/extra-oral examination of each patient (Fig. 2). Additionally, all patients were radiologically evaluated with panoramic radiographs and/or cone beam computed tomography (CBCT) scans for assessing the size and shape of the edentulous bone and for any existing pathologies. Oral hygiene status was evaluated with caution for each patient and full mouth plaque score (FMPS) and full mouth bleeding score (FMBS) were recorded from each patient before implant surgery. The number of sites where bleeding was recorded was divided by the total number of available sites in the mouth and multiplied by 100 to express the bleeding index as a percentage. In cases of poor oral health, a professional oral hygiene session was scheduled with chlorhexidine digluconate 0.2% oral rinses.

Operation technique

Starting from a day before surgery prophylactic antibiotic was prescribed to each patient, Augmentin (amoxicillin and clavulanate potassium) at a dosage of 1-g tablet every 8 hours for a total of 6 days, or Azithromycin 500 mg for 3 days as an alternative in case of allergy to penicillin.

In brief, the treatment consisted of one stage surgery for all patients: After administering local anesthesia (4% articaine with 1:100,000 adrenalin), the surgery started with a full thickness incision in the keratinized gingiva on the alveolar ridge with a #15c surgical scalpel. In cases of large defects, a wider flap was utilized for an easier access and to be able to suture the flap without extra tension which might result with a rupture at the mucogingival junction (MGJ). When a further surgical access was needed, additional vertical incisions were placed at least one tooth away from the surgical site. The maximum distance of the vertical incisions were two teeth away from the defect. Following the primary incisions, periosteal elevators were used to reflect a full thickness flap beyond the MGJ.

In cases of immediate implant insertion following atraumatic extraction of the tooth, curettage was applied to the tooth socket, followed by saline irrigation. After mechanical curettage, the infected

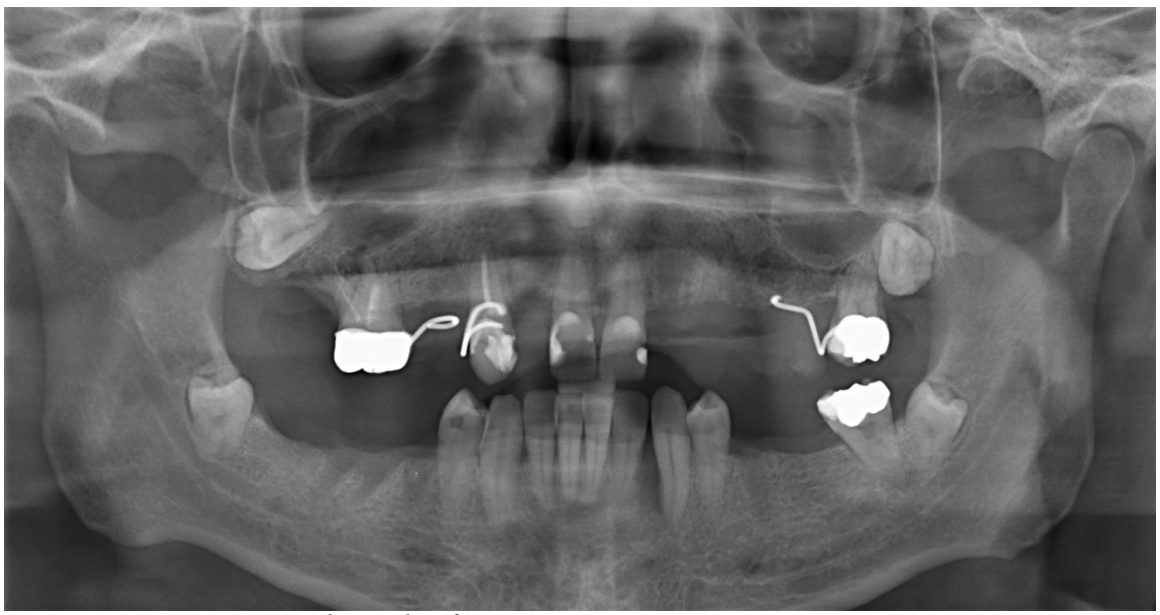

Fig. 1. *Pre-operative Panoramic radiography of a patient.*

sites were all washed with continuous irrigation of saline for an average of one to two minutes.

After flap reflection, all the bone surgeries and the implant site preparations were performed using drills and burs according to the instructions from the manufacture firms. During the osteotomy 800 RPM was not exceeded in any of the surgeries. Insertion torque for the implants ranged between 25-70 Ncm (mean 40 Ncm).

Implant insertion protocol

Manual contra-angle screwdriver was carefully inserted into the dental implants with a slight rotating motion to allow correct coupling. Fig. 3 shows intra-operative view of one of the patients during implant insertion.

As an additional note, insertion of the implants was achieved according to the following parameters:

- Bi-phase procedure with submerged implants with a speed of 15-20 RPM. Torque max 35-40 Ncm
- Monophasic procedure with immediate load/

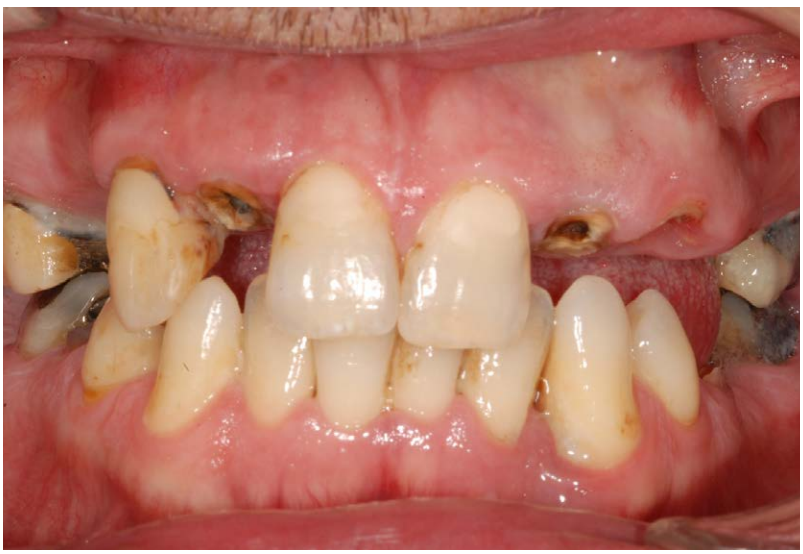

Fig. 2. *Pre-operative intra-oral view.*

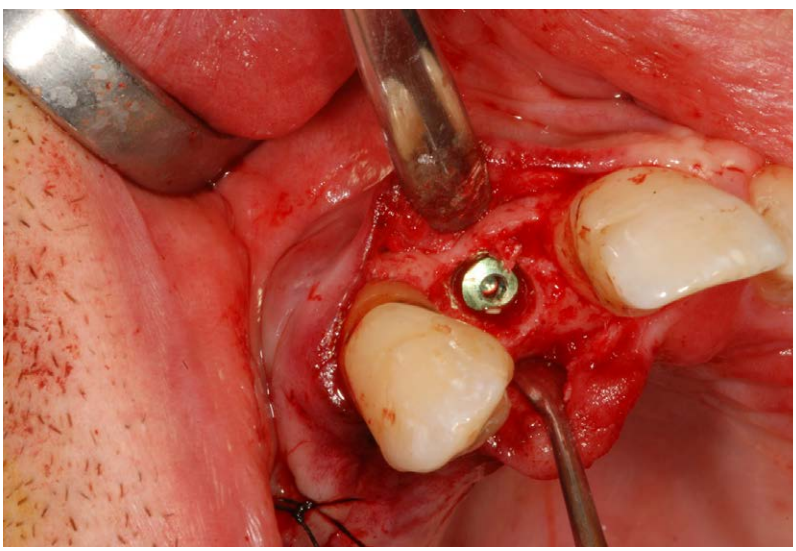

Fig. 3. *Intra-operative intra-oral view showing implant insertion.*

prosthesis: insertion with a speed of 15-20 RPM with incremental Torque 20-70 Ncm.

- Monophasic procedure realized with submerged implants and healing screws insertion with a speed of 15-20 RPM. Torque max 40-45 Ncm

The final stabilization was performed manually using the dynamometric wrench connected to the direct screwdriver with/without extension. In cases of need bone grafts, such as, xenograft/allograft or autologous bone and collagen membranes were additionally used. Finally, the wounds were repositioned and sutured with single interrupted sutures using non-resorbable silk sutures.

Follow-up

The sutures were removed 8-10 days later and standard follow-up visits, including clinical examinations were scheduled on regular basis at 1 month, 3 months, 6 months, 12 months, and then, every 6 months for the following years. All the

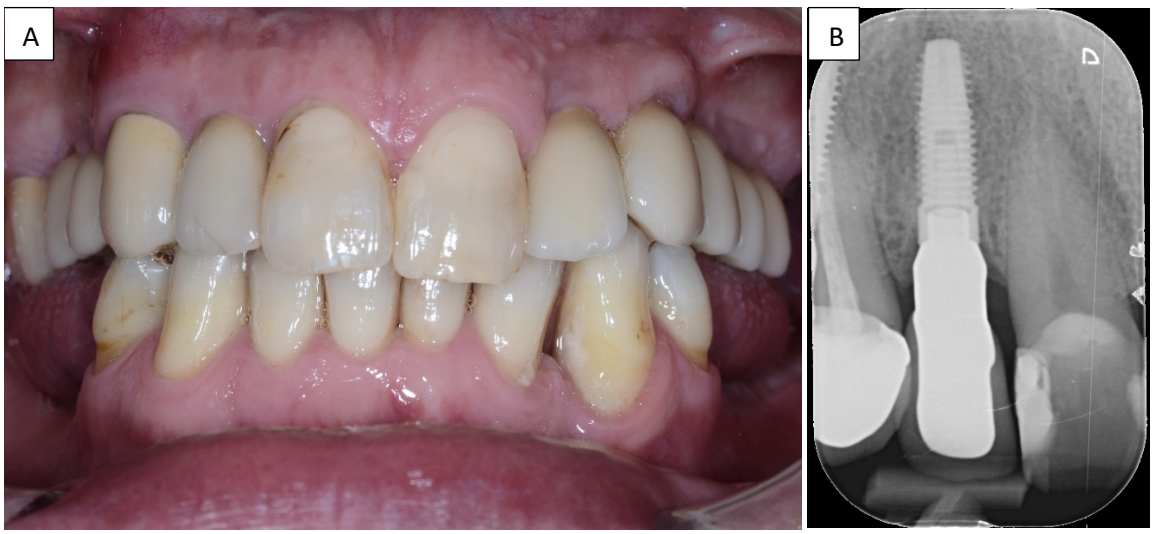

Fig. 4. *Post-operative **A)** intra-oral and **B)** periapical x-ray views of the patient at 6 months showing implant supported crown.*

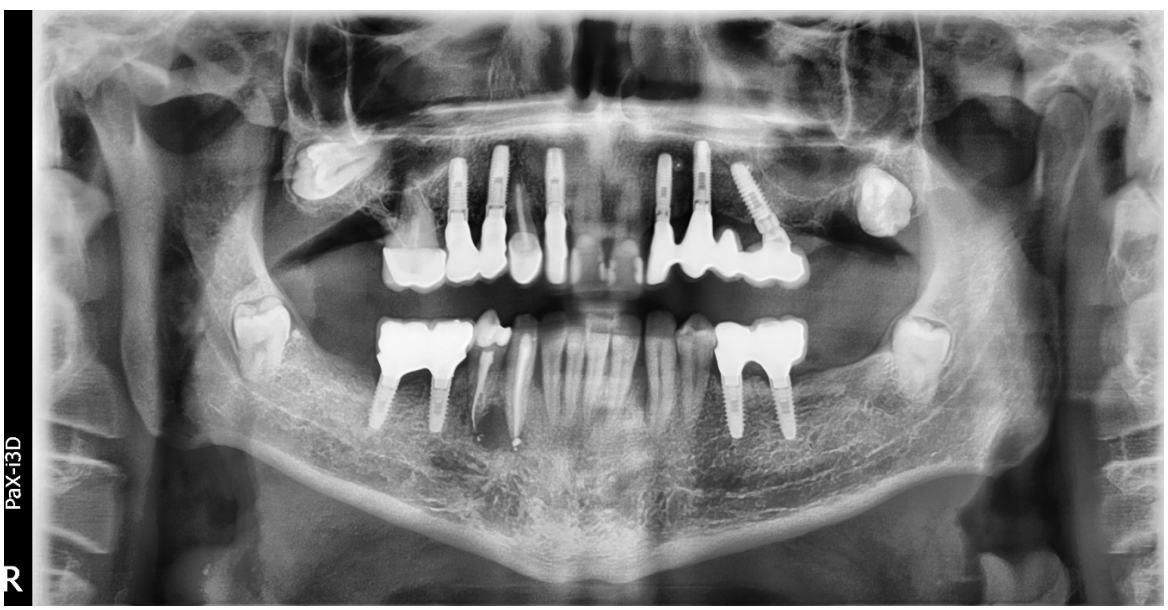

Fig. 5. *Post-operative intra-oral view of the patient after 10 years of implant insertion.*

patients received their final/temporary prosthesis using the manufacturer's components or cemented on customized abutments. Fig. 4a-b show post-operative intra-oral view and periapical x-ray of a patient after one year of implant insertion. Fig. 5-6 show intra-oral view and panoramic radiography of the same patient at 10.7 years of follow -up.

Outcomes

Implant survival and success were considered as the primary outcomes of the study. The intra-surgical and post-surgical complications were assessed as secondary outcomes. Criteria for implant survival were as follows: an implant that is still functional, supporting a prosthetic restoration and surrounded by healthy peri-implant tissues. Implants were considered successful according to the following conventional criteria established by Albrektsson (Albrektsson et al., 1986):

- absence of clinical mobility;
- no radiographic evidence of peri-implant radiolucency;
- annual bone loss of no more than 1.5-2mm in the first year of loading and 0.2 mm/year thereafter; absence of signs and symptoms such as: pain, inflammation, infection, neuropathy, hyperesthesia, invasion of the mandibular canal.

The clinical follow-up examinations were done by the same surgeon who had performed implant surgery. Periodontal status was recorded as healthy or mucositis/periimplantitis. Peri-implant bone level changes were assessed by measuring the distance between the implant shoulder and the most coronal bone-to-implant contact in mesial and distal site. The baseline was represented by the measurements taken on the day of prosthesis delivery. These were compared with those taken at least 9.5 years after insertion. The difference between follow-up and baseline measurements was considered as the BL change. Mesial and distal values were averaged to a single value per implant and per patient. The implant length and diameter served for calibration.

Date of implant surgery, type of implant, implant site, implant dimensions, post-extraction implantation (yes/no, immediate/delayed), reason for extraction, graft (yes/no, -if used type of graft), insertion torque, crestal/subcrestal implant position (transmucosal/submerged), date of prosthesis delivery, type of prosthesis (screwed/cemented), material of the temporary prosthesis, material of the

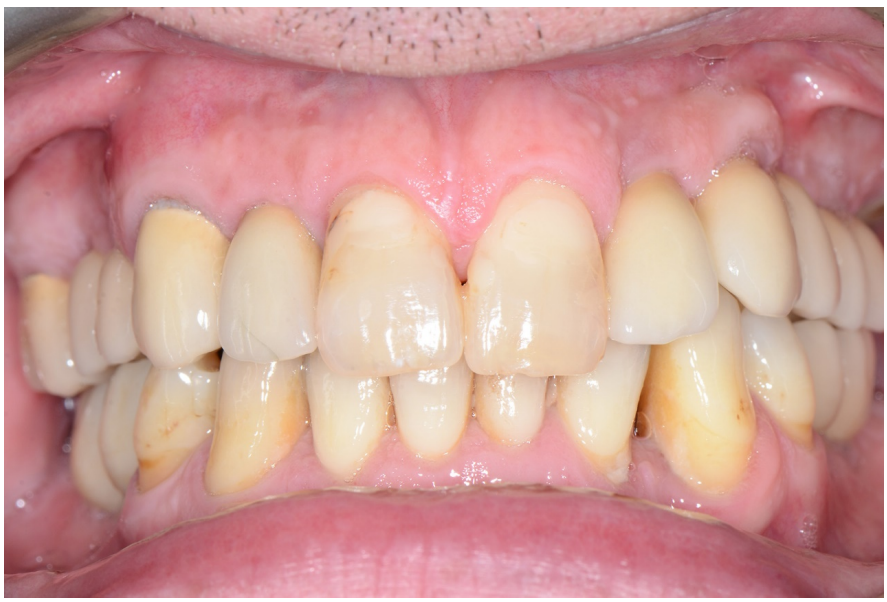

Fig. 6. *Post-operative Panoramic radiography after 10 years of implant insertion.*

final prosthesis, total follow-up period, bone loss in mms around implants, periodontal status around implants, implant survival and other complications were noted for each patient in order to use for evaluation of outcomes.

Periodontal parameters were evaluated at follow-ups. Periodontal health status of the patients especially around implants were considered as healthy in cases when there is no Bleeding on Probing (BoP) and/or inflammation. In cases of peri-implant mucositis/peri- implantitis, clinical pocket probing depth (PPD) parameters were additionally evaluated.

Mean bone level changes (mm)±*SD* from Baseline were measured from radiographs. Bone level (BL) changes were measured from radiographs after at least 6 years of follow-up.

Case peri-implant mucositis: BoP^+ and/or inflammation.

Case definition of peri-implantitis: BoP^+ and/or suppuration and BL ≥2 mm and PPD ≥4 mm.

Statistical analysis

Descriptive statistics of the data was done using mean values and standard deviation (SD) for quantitative variables normally distributed. 95% confidence intervals were also estimated. Normality of distributions was evaluated through the d'Agostino and Pearson omnibus test. The effect of each variable (age, gender, systemic condition, smoking/ drinking habits, parafunction, the reason for implants (edentulous site or post-extraction), implant location, implant platform type, implant design, prosthesis type, antagonist dentition, bone augmentation and reason for implant insertion) on implant loss or complications was evaluated by using the Fisher's exact test. The unit of analysis was the patient and implants. p=0.05 was considered as significant. Statistical analysis was performed using GraphPad Prism 5.03 (GraphPad Software, Inc., La Jolla, CA, USA).

RESULTS

The study population consisted of 49 male, 72 female patients (total: 121 patients) with 233 implants (160 conical, 73 cylindric implants). Mean age of patients at the time of surgery was 51 years (SD 12.73).

The patients with general health problems can be listed as follows: 9 cardiac pathology, 6 renal pathology, 6 high cholesterol, 1 anxiety, 1 myocarditis, 3 diabetes. All these systemic health conditions were under control and were not considered as a reason for exclusion.

Full mouth plaque score (FMPS) and full mouth bleeding score (FMBS) were recorded from each patient before implant surgery. According to the data, the full mouth plaque score (FMPS) ranged between 0-50% (MED 20%) and full mouth bleeding score (FMBS) ranged between 0-50% (MED 15%).

List of reasons for tooth extraction before implant insertion is as follows: 64 caries, 3 trauma, 4 fracture,11 periodontitis, 10 endodontic problems, 29 edentulous since a long time (the reason for extraction was unreported by the patient).

200 implants were inserted without any additional augmentation procedures, while 33 implants had augmentation at the implant sites with Bio-Oss© (Geistlich Biomaterials, Italia) or with Gen-Os© (OsteoBiol, Italy) (28 implants with Bio-Oss© Bioss, 4 implants with Gen-Os©).

According to the data, 83 implants had temporary prosthesis while and 150 implants had no temporary prosthesis after insertion. All the patients in the study group had final prosthesis delivered and mean prosthesis delivery interval after implant insertion was 7.49 months (SD 4.95 months) (0 to 34.37 months).

The final implant prosthesis materials were as follows: 12 Zirconium-ceramic, 90 Metal-ceramic, 1 Targis-vectris, 4 Resin, 3 Lithium disilicate, 2 Gold-Resin, 2 Metal-resin, 119 Ceramic.

Intra-operative complications were seen in 5 patients: 2 hemorrhage, 1 fenestration, 2 perforation of the bone. Post-operative complications were recorded for 10 implants: 5 mucositis,1 dehiscence, 2 screw loosening, 1 infection at site (implant failure), 1 non- integrated implant (implant failure).

27 patients had previous periodontal problems (1 implant failure was seen in a patient with periodontal problem/ 1 implant failure in a patient without previous soft tissue problems).

Mean follow-up was 12.29 years (SD 1.39) with a range between 10.07-17.68 years, and the median

follow up was 12.66 years (95%CI: 12.25, 12.63). Bone loss measurement around implants was done for each dental implant after at least 9.5 years of insertion date (mean 10.5 years (SD 1.9 years) (min 9.5 years-max 14.12 years). According to the results mean bone loss calculation was 2.0 mm (SD 0.73 mm).

According to the results of this present study, there were no dropouts, and the implant survival rate was 99.1 %. Two implants (cylindric and sub-crestal) had failures:

- One implant (maxillary site, positioned at 23, dimensions 3.75x13) was lost in a 35-year-old male patient after 17 days of insertion due to infection at the site. This patient had a total of 6 implants inserted, represented 20% FMBS and FMPS values before surgery and had a chronic generalized periodontitis history. The patient was a smoker and was drinking alcohol more than 2 glasses a day. He had no health problem and no parafunction. The patient had no other intra/post-operative complications.
- One implant (maxillary site, positioned at 33, dimensions 3.75x13) was lost in a 57-year-old female patient after 9.8 years of insertion. This patient, otherwise healthy, had just one implant inserted, which had failed. This patient represented 5% FMBS and FMPS values before surgery and had no periodontal problem history. The patient was a smoker and was not a drinker of alcohol. She had no health problem and no parafunction. The patient had no other intra/post-operative complications.

Implant survival rates for comparison of different implant characteristics such as, the reason for implants (edentulous site or post-extraction), implant location, implant platform type, implant design, prosthesis type, antagonist dentition and bone augmentation are listed in Table I. In Table II, detailed data of the study group and the effect of different variables such as; gender, age, systemic condition, smoking (yes or no, independent of the amount of smoking), alcohol abuse (more than 2-3 glasses a-day), and parafunction on implant success is analyzed.

The results of this study showed that implant survival was not influenced by age, gender, systemic condition, smoking/drinking habits, parafunction, bone augmentation, implant location, implant platform type, implant design, antagonist dentition and reason for implant insertion. Prosthesis type and material had no effect on implant failure. There was no significant effect of using temporary prosthesis, cemented or screw or overdenture prosthesis with locator on implant success.

In Table III, the data concerning implant numbers and dimensions are shown. Detailed data for implant site (mandible, maxilla, and location) are illustrated in Fig. 7 and Fig. 8. The cumulative incidence of complications estimated with Kaplan-Meier analysis, showing implants without complications and follow up period are listed in Table IV.

DISCUSSION

There are several studies showing that rehabilitation with osseointegrated implants is a valid and predictable technique in the long term, even in patients presenting difficult situations that require pre-implant bone reconstruction techniques (20-34).

Periodontal situation and surface characteristics can have an impact on success of dental implants in long term. According to the literature implant survival rate with TPS surface implants at 10 years ranges from a minimum of 85% [a study on patients with periodontal problems (35)] up to 100%[a study with TPS surface (36)]. Studies that evaluated SLA surface, reported similar results ranging from 89.2% (transmucosal SLA surface) (37) to 95.9% (25) of survival at 10 years (25,37). Another study with follow-up of up to over 11 years compared the success of 513 transmucosal implants with TPS or SLA surface in 110 periodontally healthy patients (NSP), 68 with chronic periodontitis (CAP) and 16 with generalized aggressive periodontitis (GAP) (38). According to results, the survival rate of implants with SLA surface was higher than those with TPS surface (97% vs. 93%) (38).

Pozzi & Mura in a retrospective study performed clinical and radiographic evaluations of oxidized rough surface implants with a follow-up of up to 10 years and reported a marginal bone loss of 1.72±1.53 mm and 1.27±1.67 mm for cylindrical and conical

Table I. *Implant survival rates for comparison of different characteristics.*

Patient	Characteristics	Implant failure / Total no of Implants	Success %	*p-value*
Reason for Implants	Edentulous site	2/185	98.9	0.63*
	Post-extraction (immediate)	0/13	100	
	Post-extraction (early)	0/2	100	
	Post-extraction (delayed)	0/33	100	
Implant location	Maxilla Incisive	1/29	96.6	0.50**
	Premolar	0/46	100	
	Molar	0/33	100	
	Mandible Incisive	1/15	93.3	
	Premolar	0/46	100	
	Molar	0/64	100	
Implant Platform	Crestal	0/110	100	0.28
	Subcrestal	2/123	98.4	
Implant design	Conic	0/160	100	0.10
	Cylinder	2/73	97.3	
Temporary prosthesis	Yes	1/83	98.8	0.46
	No	1/150	99.3	
Type of prosthesis	Screw	0/75	100	0.11
	Cemented	1/135	99.2	
	Locator/Overdenture	1/23	95.7	
Antagonist dentition	Natural teeth	2/173	98.8	0.54***
	Total denture	0/3	100	
	Resin prosthesis	0/13	100	
	Ceramic Crown	0/35	100	
	Implant plus crown	0/7	100	
	Removable prosthesis	0/2	100	
Bone Augmentation	Yes	0/32	100	0.74
	No	2/201	99.0	
Total		2/233	99.1	

**edentulous vs postextraction; **maxilla vs mandible; ***natural teeth vs. any type of prosthesis*

implants, respectively, and a survival rate of 100% (39). Another retrospective study evaluated the long-term dental implant survival rates of Straumann dental implants in a university hospital environment. As a result, they reported long-term implant survival rate as 88.03% after an observation time of 12.2 to 23.5 years (8). A proportion 82.8% of the patients with implant losses had a medical history of periodontitis. Peri-implantitis was diagnosed in 9.7% of the remaining implants in the long-term survey (8).

A prospective cohort study examined the survival rate and incidence of peri-implantitis at 10-year

Table II. *Implant survival rates for comparison of different patient specific characteristics.*

Patient	Characteristics	Implant failure / Total no of patients	Success %	*p-value*
Gender	Male	1/49	98.0	0.49
	Female	1/72	98.6	
Age	≤60	2/99	97.9	0.67
	>60	0/22	100	
Smoking	yes	2/59	96.6	0.24
	No	0/62	100	
Alcohol	yes	1/27	96.3	0.35
	No	1/95	98.9	
Systemic condition	ASA 1	2/90	97.8	0.55
	ASA2	0/31	100	
Parafunction	yes	0/21	100	0.68
	no	2/100	98	
TOTAL		2/121	98.3	

**statistically significant difference*

Table III. *Implant numbers and dimensions.*

	IMPLANTS LENGTH					
IMPLANTS WIDTH	6	8	10	11.5	13	Total
3.25	0	1	8	0	4	13
3.75	0	5	48	39	19	111
4.25	2	0	3	2	0	7
4.5	0	1	29	30	8	68
4.75	0	0	12	3	0	15
5.5	0	1	10	8	0	19
Total	2	8	110	82	31	233

Table IV. *The cumulative incidence of complications estimated with Kaplan-Meier analysis, showing implants without complications and follow up period.*

interval	implants at risk	lost to follow-up	failures	interval survival rate	cumulative survival rate
0-1y	233	0	1	99.57%	99.57%
1-3y	232	0	0	100.00%	99.57%
3-6y	232	0	0	100.00%	99.57%
6-9y	232	0	0	100.00%	99.57%
9-12y	232	79	1	99.57%	99.14%
12-15y	152	134	0	100.00%	99.14%
15-18y	18	18	0	100.00%	99.14%

follow-up, considering 374 implants (SLA surface) in 177 patients. Mean bone loss at 10 years after loading was 0.52 mm with the survival rate showing 99.7%-99.4%, considering implants, and by analyzing the patient, respectively (40). Generally, in all these studies, the survival percentages were better in patients who did not previously present periodontitis.

In this study, the follow-up ranged between 10 to 17.7 years. All the implants inserted had a pure aluminum sandblasted-acid etched surface and the survival rate was 99.1 % which was similar to the results obtained by other researchers. In the population group, 27 patients had previous periodontal problems and 1 implant failure was seen in a patient with a periodontal problem and 1 implant failure in a patient without previous soft tissue problems. None of the failures had pre-implant bone reconstruction/augmentation techniques. According to the results of this study, it cannot be concluded that soft tissue problem history has any effect on dental implant failures.

In a review article in 2005, the long-term success of dental implants was evaluated (28). As a conclusion, they reported an optimum general performance of

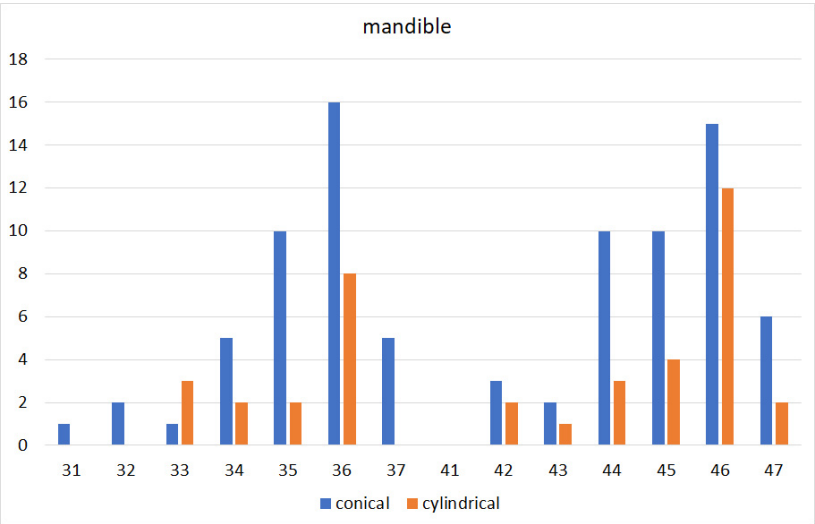

Fig. 7. *Detailed data for distribution of dental implants at mandibular site.*

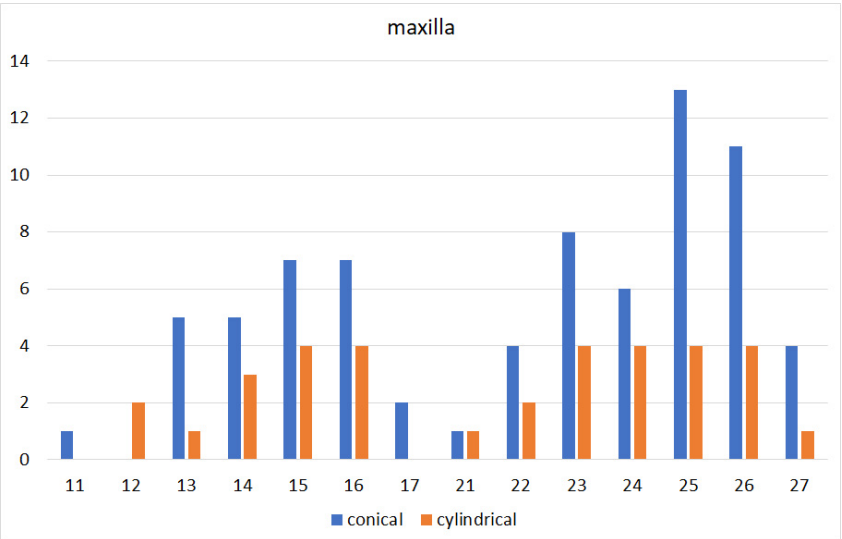

Fig. 8. *Detailed data for distribution of dental implants at maxillary site.*

long-term implant treatment and a diversification of the peri-implant bone loss pattern with various implant systems and surfaces. However, in the long-term (10 years) a limited bone loss is achieved with an overall implant success rate in the range of 85% or more for all implant systems. A more recent systematic review evaluated the success and survival of dental implants with at least 10 years of follow-up (41). The survival rate was reported as 96.4% with mean marginal bone resorption of 1.3 mm, and the authors concluded that osseointegrated implantation is a safe treatment modality with high survival rates and limited bone loss even in the long-term (41). In this present study, the mean follow-up was 12.44 years and the median follow up was 12.66 years (95%CI: 12.25, 12.63). Bone loss measurement around implants was done for each dental implant after at least 6 year of insertion date. According to the results mean bone loss calculation was 2 mm SD 0.73 mm at a mean follow up of 10.5 years after of their insertion, and this result can be considered as successful.

A prospective study assessed the long-term clinical outcome of single implants inserted by flapless or conventional surgery and reported that flapless free-handed surgery for single implants with neighboring teeth is a predictive treatment, in cases when there is sufficient bone volume (42). Salvi et al. investigated the long-term biological complications of dental implants placed either in pristine or in augmented sites in a systematic review and meta-analysis (16) and reported no statistically significant results. According to the results of this study, none of the patients with implant failures had pre/intra implant bone reconstruction/augmentation procedures and reconstruction/augmentation before or during implant surgery no effect on dental implant failures.

In general, regardless of the implant system and of the surface, the implants that fail also represent constant bone loss in time. Additionally, these results seem to be associated with various patient specific factors that are unrelated to the type and surface of the implant, but can be caused by biomechanical problems, prosthetic problems or with systemic or local conditions of the patient (infections, diseases that interfere with the healing process).

In a very recent systematic review, the risk factors related to the late failure of dental implants were evaluated (43). This study group divided the common risk factors for late failure into three groups: (1) the patient history (radiation therapy, periodontitis, bruxism, and early implant failure), (2) clinical parameters (posterior implant location and bone grade 4) or (3) decisions made by the clinician (low initial stability, more than one implant placed during surgery, inflammation at the surgical site during the first year or using an overdenture with conus-type connection). As a result, they reported that clinicians should be cautions throughout the treatment process of dental implant—from the initial examination to the treatment planning, surgical operation, and prosthesis selection—in order to minimize the risk of late failure of dental implant.

According to the results of this present study, the overall implant survival rate was 99.1 %. Implant survival rates for comparison of different implant characteristics such as, the reason for implants (edentulous site or post-extraction), implant location, implant platform type, implant design, prosthesis type, antagonist dentition and bone augmentation had no impact on implant success. This study showed that implant survival was not influenced by age, gender, systemic condition, smoking/drinking habits, parafunction, bone augmentation, implant location, implant platform type, implant design, antagonist dentition and reason for implant insertion. Prosthesis type and material had no effect on implant failure.

As a conclusion, oral rehabilitation with dental implant-supported prostheses can be accepted as a safe procedure with relevantly high survival rates of oral implants and successful aesthetic and functional outcomes. The retrospective design of this study can be considered as one of the limitations of this study. Currently, with the increasing demand for placement of dental implants from patients, there is still a need in literature, to appraise the highly varied evidence with long-term results that is currently available for helping clinical decisions.

Author contributions

F.G., and M.D.F. conceived and designed the study. The surgical interventions were performed by S.A., M.C., M.B., M.T., and F.C. Data collection

form was prepared by M.D.F. and F.G. Data were collected by S.A., M.C, M.B., M.T., R.B, A.G.L. and F.C. All the authors contributed on analysis and interpretation of data for the work. M.D.F. and F.G. drafted the work and wrote the manuscript with input from all authors. All authors revised the work critically for intellectual content. Integrity of the work was appropriately investigated and resolved by all authors. All authors contributed, read, and approved equally to the final manuscript.

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