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Implant survival and success rates in patients with risk factors: results from a long-term retrospective study with a 10 to 18 years follow-up

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Abstract. – OBJECTIVE: Risk factors for implant therapy are represented by all general and local conditions that through various mechanisms can increase either short-term and long-term failure risk. The aim of this study is to assess the implant survival and implant success rates with single and multiple risk factors.

PATIENTS AND METHODS: To address the research purpose, a retrospective cohort study was designed and implemented, including a sample of 225 patients with a total of 871 implants placed. The following risk factors were considered: smoking, bruxism, bone augmentation procedures and the presence of load risk (implants with crown/implant relation > 0.8; angulation > 25°; presence of cantilever).

Follow-up ranged from 10 years to 18 years (average follow-up 13.6 years).

Failures were subdivided into short-term failures, before the prosthetic phase, and long-term failures, after definitive prosthesis. The success criteria published by Albrektsson and Zarb were adopted. A Cox proportional hazard regression model was used to calculate hazard ratio, with a statistically significant *p*-value <0.05.

RESULTS: Out of the 871 implants placed, 138 did not meet the success criteria, (success rate 84.16%), sixty (43.47%) were classified as "early failure" and seventy-eight as "late failure" (56.53%). A total of 70 dental implants were removed, with a survival rate of 91.96%.

CONCLUSIONS: The presence of a single risk factor does not imply a marked increase of failure risk. Among the analyzed factors, the one that proved to be the most dangerous was bruxism, even when presented as the only risk factor. Bruxism with load risk proved to be the most dangerous association (success rate 69.23%) and could be included among the absolute contraindications for implant treatment.

Key Words:
Dental implant, Risk factors, Lateral loads, Smoking, Bruxism, Bone regeneration, Implant survival, Implant success.

Introduction

A successful implant rehabilitation depends on the correct implementation of both clinical and laboratory phases, as well as on an accurate selection of patients[1,2]. However, nowadays, also patients with one or more risk factors are treated with dental implants.

Research on implant alloys, surfaces and coatings have been utilized to try to maximize ongrowth potential and secondary stability, increasing bone to implant contact values (BIC)[3,4].

Moreover, soft and bone tissue augmentation procedures, as well as the presence of reduced-diameter dental implants and the accuracy of digital implant planning software and templates, allow clinicians to treat patients with a wider range of clinical situations[5-7].

The presence of multiple risk factors makes harder to establish an objective evaluation of the risks in each single case[8-10]. Risk factors for implant therapy are represented by all general and local conditions, which influence negatively both surgical and prosthetic phases of treatment, increasing short and long-term failure risk[10,11]. In this retrospective study, the following risk factors were considered: smoking habit, bruxism[12-14], bone augmentation procedures associated with implant placement and presence of load risk (LR) on implants. LR was defined by the presence of one or more of the following factors: implants with crown/implant relation > 0,8; implants with angulation superior to 25° and cantilever.

Other risk factors are represented by coagulation disturbs, type 1 and type 2 diabetes, Crohn's disease, osteoporosis, hyperthyroidism, chemotherapy and radiotherapy for head and neck cancer[15-17].

The purpose of this study was to evaluate how different risk factors, single or combined, affect implant survival and success rates.

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The investigators hypothesized that dental implants placed in patients with a single risk factor had similar results, while subjects with multiple factors combined could show higher failure rates.

Patients and Methods

To address the research purpose, the authors designed and implemented a retrospective cohort study, conducted at the Department of Oral and Maxillofacial Sciences, at the "Sapienza" University of Rome, approved by the institution review board (ref. no 3452).

The study sample was composed of a population derived from patients presenting at the university's department for implant placement, in an interval of time between 1998 and 2006.

To be included in the study sample, patients had to meet specific inclusion and exclusion criteria.

Subjects eligible for the study inclusion performed an implant treatment, had age $\geq$ 18 and one or more of the following risk factors: diagnosis of bruxism, smoking habit, bone augmentation procedures and load risk. All subjects provided signed informed consent according to the World Medical Association's Declaration of Helsinki.

Patients were excluded from enrollment to the study if they had an uncontrolled systemic disease, a history of mental disorders, presence of incomplete medical records or refused to enroll to this study.

From a total population of 456 patients with a mean age of 55.6 (range 18-79 years), who presented at the university's department for implant treatment, a final cohort of 272 subjects, with a total of 1034 dental implants placed, complied with all the required inclusion criteria.

Follow-up ranged from 10 years to 18 years (average follow-up 13.6 years).

Patients were divided into four groups, based on their specific risk factor:

– group A: bruxism;
– group B: smoking habit (more than 10 cigarettes/die);
– group C: bone augmentation procedures;
– group D: risks load (RL)

In the case of multiple risk factors, groups were identified as following: AB, AC, ABC, and ABCD.

Surgical Phase

One hour before surgery, prophylactic antibiotics were administered to the patients: 2 g of amoxicillin and clavulanic acid (Augmentin; Roche S.p.A., Milan, Italy) or, in the case of penicillin allergy 500 mg of azithromycin (Zithromax; Pfizer Italia S.r.l., Latina, Italy). Chlorhexidine digluconate 0.12% mouthwash (Dentosan Collutorio Trattamento Mese; Recordati S.p.A., Milan, Italy) was prescribed every day for 7 days after surgery, and all patients were required to provide written consent for implant treatment.

All implants were placed according to the manufacturer's standard instructions, in all cases, a two-stage healing protocol was adopted.

Bone Augmentation Procedures

In the case of guided bone regeneration (GBR), either synthetic bone substitutes (HA and beta-Tricalcium Phosphate) or xenografts (demineralized bovine cortical bone) were used, mixed with autologous patient's bone collected during osteotomy with implant burs. In all procedures, a collagen membrane was associated with bone regeneration.

Prosthetic Phase

The second surgical phase was performed after two months in the mandible and four in the maxilla.

Fixed Single and multiple crowns, both screw-retained and cemented-retained, were performed, as well as removable overdentures.

Statistical Analysis

Descriptive statistics were computed for each variable of the study. A p-value <0.05 was considered statistically significant. A Cox proportional hazard regression model was used to calculate hazard ratio. A specific statistical software (IBM SPSS V10 Statistics, IBM, Armonk, USA) was used to analyze the data.

Results

On a total sample of 272 patients, forty-seven subjects (17.27%) were excluded from the study for several reasons: death (9), interruption of smoking habit (27), missing data from medical records (11). Sample variables were collected in Table I.

A final cohort of 225 patients with 871 implants was included in the study, 138 did not meet the adopted success criteria, with a success rate of 84.16%.

Out of the 138 failures occurred, sixty (43.47%) were classified as "early" and seventy-eight as

Table I. Patient's demographic.

Demographic variables	
Mean age (years)	55.6 (range 18-79)
Sex	
Male	145 (64.44%)
Female	80 (35.56%)
Anatomic variables	
Jaw	
Maxilla	140 (62.22%)
Mandible	85 (37.78%)
Location	
Anterior	128 (56.89%)
Posterior	97 (43.11%)
Prosthetic variables	
Fixed	195 (86.66%)
Removable	30 (13.44%)
Bone augmentation procedures	
Yes	35 (15.55%)

"late" (56.53%). A total of 70 dental implants were removed, with a survival rate of 91.96%. Data divided for risk factors were summarized in Table II and Table III.

Discussion

The specific aims of this study were focused on evaluating retrospectively, with a long-term follow-up, the effects of single and multiple risk factors on implant failures. Failures can be classified into early failures, which occurred before prosthetic finalization, and late failures, which occurred after application of occlusal load[9,10]. Early failures are always biological, while late failures can be classified into biological and mechanical. Biological failures are caused by an inflammatory process of peri-implant tissues or by occlusal overload[17-19]. Mechanical failures include fixture fracture, abutment screw loosening and fracture[20,21]. Smoking affect wound healing in several ways: it reduces migration capacity of stromal cells around implant surface during osseointegration, directly irritates soft tissues healing and prevents mucous seal after osseointegration[22]. Bruxism is a common parafunctional habit, which induces damage of dental surfaces and results in loss of dental tissues, occurrence of wear facets, loss of vertical dimension, temporomandibular disorders, and neuromuscular pain. It is generally accepted that bruxism determines implant and prosthetic overload though, according to the literature available, it is not possible to establish a direct cause-effect correlation between bruxism and implant failure[23-26]. The use of

Table II. Risk factors analysis. Group A: bruxism; group B: smoking habit (more than 10 cigarettes/die); group C: bone augmentation procedures; group D: risks load (RL).

Group	Patients	Implants	Failures Early	Failures Late		Success	Implants in function	Survival
A	33	116	12	3	9	89.66%	113	97.41%
B	24	85	6	4	2	92.94%	80	93.75%
C	15	30	1	-	1	96.67%	29	96.67%
D	18	58	5	-	5	91.34%	57	98.28%
Tot 1	90	289	24	7	17	91.7%	279	96.54%
AB	23	78	13	5	8	83.33%	69	85.90%
AC	14	80	10	4	6	87.5%	76	95%
AD	21	104	20	8	12	80.77%	94	90.38%
BC	19	66	12	6	6	81.82%	60	90.91%
BD	15	59	9	6	3	84.75%	53	89.83%
CD	3	11	1	-	1	90.91%	11	100%
Tot 2	95	398	65	29	36	83.67%	363	91.21%
ABC	15	86	18	12	6	79.07%	74	86.05%
ABD	22	78	24	7	17	69.23%	68	87.18%
ACD	-	-	-	-	-	-	-	-
BCD	-	-	-	-	-	-	-	-
Tot 3	37	164	42	19	23	74.39%	142	86.58%
ABCD								
Tot 4	3	20	7	5	2	65%	15	75%
Tot	225	871	138	60	78	84.16%	801	91.96%

Table III. Multivariate Cox model (adjusted) (n=225 patients and 225 implants), values *are statistically significant ($p<0.05$).

	Hazard Ratio	*p*-value
Demographic variables		
Mean age	0.99	0.65
gender	0.73	0.30
Health-status variables		
Smoking	3.1	0.01*
Bruxism	2.9	0.02*
Implant-specific variables		
Implant length	0.96	0.55

bone augmentation procedures result in a higher risk of surgical failure[27] and longer waiting times, with success rate strongly linked to the correct execution of surgical phase and absence of post-operatory complications[27,28].

The choice of inserting implants with a non-ideal length, diameter, and angulation is somewhat compelled either by patient's decision to do not undergo bone augmentation procedures or by some specific reasons occurred during surgical procedures. In these cases, implants will be exposed to lateral loads, resulting in Inevitable Lateral Loads, defined by the presence of one or more of the following factors: implants with crown/implant relation > 0.8; implants with angulation superior to 25° and cantilever. In our retrospective study, among patients with a single risk factor, the worst results were obtained by Group A, with a success rate of 89.66% and both biological and mechanical failures. On the other hand, Group D showed 5 mechanical failures out of 58 implants inserted. Survival rate was 98.28%, as in four cases mechanical problems were solved. Group C (15 patients, 30 implants) obtained a 100% success rate, confirming that this conditions may be considered as a risk factor of minimal importance when presented singularly. On the contrary, bone augmentation procedures proved to be an additional risk factor if associated with other groups, especially with the smoking habit. The success rate of implants placed in patients of Group BC was statistically significant ($p<0.05$) lower (81.82%) compared to Group B (92.94%) and Group C, with only biological failures occurring. The association of bruxism and bone regeneration (Group AC) resulted in a lower success rate (87.50%), compared to Group A (89.66%). Though this difference was not statistically significant ($p>0.64$), it is interesting to note that only mechanical failures occurred in Group A, while failures in Group AC were all biological. Group CD showed a success rate of 90.91% and a survival rate of 100%, but this association was not statistically significant ($p>0.66$), as regarding only three patients and a total of 11 implants.

Groups with three risk factors included the association of smoking, bruxism and bone augmentation procedures (group ABC) and RL (ABD): success rate values were statistically significant ($p<0.05$) lower, decreasing to 69.23% in Group ABD.

Three patients presented four risk factors combined (ABCD), with a total of 20 implants placed: five resulted in an early biological failure, 2 showed mean marginal bone loss values higher than 3 mm, while the others appeared to be perfectly stable and showed no signs of bone reabsorption to date. The success rate was 65% and survival rate 75%.

Conclusions

The choice of implant treatment in patients with risk factors should be carefully evaluated, however, within the limitations of this study and the possible bias derived from its retrospective nature, it can be concluded that the presence of a single risk factor may not imply an increase of failure risk. Among the analyzed factors, the one that showed the worst results, when presenting alone, was bruxism, while the most dangerous association was between bruxism and lateral loads, resulting in both mechanical and biological failures.

The association of bruxism, smoking, and RL represented a particularly risky circumstance with a success rate of 69.23%. This condition should be included among the absolute contraindications for implant treatment.

Conflict of interest

The authors declare they have no conflict of interest and gave all their approval to the final version of this manuscript.

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