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Case Report

Implant failure rate and the prevalence of associated risk factors: a 6-year retrospective observational survey

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Abstract – Introduction: The purpose of this monocentric retrospective observational investigation is to evaluate the implant failure rate observed in an oral surgery department and analyze the risk factors associated with them. Preventative measures will be suggested to reduce the incidence of implant failure. **Material and method:** All implants removed between 2014 and 2020 were analyzed. The main criterion assessed was the overall failure rate over 6 years of activity; the secondary criteria were the risk factors associated with implant failure. **Results:** 12 out of 376 implants placed between 2014 and 2019 in 11 patients (mean age: 55.5 ± 11.5 years); sex ratio M/F = 5/6) were removed, for an overall failure rate of 3.11%. The majority, 83% (10/12) of the lost implants, were in the maxilla, while only 17% (2/12) were placed in the mandible. The main risk factors identified were: a III–IV bone type density (75%, 9/12), pre-implant sinus lift surgery (42%, 5/12) smoking (8.3%, 1/12), surgical site infection (8.3%, 1/12) and rheumatoid arthritis (8.3%, 1/12). **Conclusion:** The failure rate observed in this oral surgery unit is consistent with the other international studies, confirming the compliance with good clinical practices of the healthcare team. Pre-implant bone surgery is the major risk factor to consider before implant surgery.

Introduction

The use of dental implants is now a reliable treatment for edentulism with a success rate of 97% at 10 years and 75% at 20 years [1,2]. As in any surgery, complications may arise, which may lead to loss of the implant. Implant failures are categorized as either early (<3 months) or late (>3 months). Causes of early implant failure include excessive heating of the bone during drilling, over-preparation of the surgical site or low-density bone that interferes with the primary stability of the implant. Conversely, late implant failures are usually from infectious origin. The most common are peri-implantitis present in 34% of patients [3]. In other cases, although the implant may be perfectly osseointegrated, it must be removed because it is in a poor prosthetic position. Overbite and parafunctions can be aggravating factors. Most late failures present no implant mobility because implants always have excellent osseointegration in their apical section. The purpose of this study is to evaluate the rate of implant failure observed in an Oral Surgery department over a 6-year period and to analyze and discuss risks factors associated within it.

This study found a failure rate of 3.11%, while the most common complication was peri-implantitis and the most important risk factor was type III/IV bone, more precisely pre-implant surgery with sinus elevation.

Peri-implantitis is a major complication and still occurred in approximately 28–77% of the subjects as well as in 12–43% of the implant sites [4].

Pre-implant surgery is an important risk factor for the failure rate so it requires special treatment conditions to reduce the failure rate [5]. However, the failure rate for preimplant sinus lift surgery remains high.

The overall failure rate found in a recent study is about 2.1% according to Castellanos-Cosano *et al.* [6], we will correlate its results to ours. The occurrence of peri-implantitis will also be compared to Papaspyridakos' results (1.6%) [7] and the major risk factor recognized as pre-implant surgery for posterior maxilla to Chaware's research (4.2%) [8].

Others risk factors will be developed such as active smoking, rheumatoid arthritis, anti-hypertensive drugs and surgical site infection.

The analysis of those risk factors associated with implant failure will indicate areas of improvement for therapeutic management.

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Methods

Study population

This retrospective study was conducted by analyzing files of patients that received dental implant in the oral surgery department at Nanterre CASH between 2014 and 2020.

Inclusion criteria

Implant failure in the present study is defined as "implant removal", regardless of the technique or etiology. The inclusion criteria were patients of all ages and gender with implant failure following the placement of at least one dental implant in compliance with implant contraindications. Dental care and periodontal management was performed by the treating practitioner prior to implant surgery. All patients followed a periodontal maintenance program before and after surgery.

Exclusion criteria

Patients without implant treatment and patients with implant success on one or more placed implants were excluded from the study. Implant success was defined as "functional, tolerated and does not require removal".

Risk factors associated with failure

The analyzed variables were: age of the patient at the time of implant placement, gender, systemic diseases, harmful habits, bone density according to the Lekholm & Zarb classification [9], implant position, number of implants placed, implant length and diameter, and pre-implant bone surgery.

Clinical and additional examinations

A standardized comprehensive examination was performed on patients consulting for implant failure. This examination consisted in obtaining full medical and dental history using a survey and with a medical interview, supported by an intraoral, periodontal examination and radiographic images. A thick keratinized mucosa of at least 2 mm in the peri-implant area was sought and obtained by periodontal planning when absent. All patients were recalled and provided written informed consent after being informed of the study objectives. The consent document was written following the "World medical association declaration of Helsinki".

Failure rate

Data from the 6-year period was extracted from the clinic's DMI (Implantable Medical Devices) traceability software managed by the Pharmacy of the hospital. The following parameters were recorded by a hospital practitioner qualified in oral surgery:

- Chronology of failure: date of implant placement and removal, date of diagnosis of the implant failure.
- Type of failure: Poor osseointegration, loss of osseointegration, occlusal dysfunction, infection.

The medical and dental history determined the early or late character of the implant failure. Occlusal analysis was only indicated for late failures after crown loading.

Risk factors

Data regarding the implant site and clinical conditions were reviewed:

- Clinical conditions: Bone type, type of pre-implant surgery, timing of occlusal loading.
- Clinical signs and symptoms: edema, infection, pain, suppuration, paresthesia, bone loss, dehiscence.
- Risk factors: Tobacco, parafunctions, hygiene, organ transplant, medical history.

Statistics

The averages of the data were calculated using Excel software developed by Microsoft 365 then expressed as a percentage, results were expressed as means and standard deviations. Statistical analysis was performed with exact Fisher's test by using biostaTGV software for the purpose of an average comparison.

Results

Study population

376 implants were placed between February 2014 and February 2019 (Tab. I) in 202 patients by 4 senior practitioners. Failures occurred for 11 patients, 5 males and 6 females, aged from 42 to 78 years (Mean age: 55.5 ± 11.5) (Tab. II).

Failure rate

Out of the 376 implants placed, 12 implant failures were recorded during the period of 2014–2020 (Fig. 1), this equates to an overall failure rate of 3.11% ($\sigma = 2.38\%$) over a 6 years follow-up. We noted that the year 2016 showed an increase in surgical activity. There were more failures on implants placed in 2016 representing 41.67% of total implant failures (5/12; Tab. I). For that year, the failure rate was 7.14%, a statistical analysis found a significative difference compared to the mean of other years ($p = 0.05$; OR = 0.30).

Nb: Implants N°11 and 12 were placed in the same patient (cf. Tab. I).

According to Table I, late failures (9/12) were more frequent than early failures (3/12). Early failures showed a lack of osseointegration, while late failures were the result of bone loss due to peri-implantitis (2.32%, $\sigma = 1.95\%$). Clear clinical

Table I. Clinical data and characteristics of implant failures (RA: Rheumatoid Arthritis; HTN: Hypertension).

Implant	Sex	Age	Bone type	Bone	Sector	Health status	Insertion	Time	Preimplant surgery	Dimensions
1	Woman	51	II	MD	POST	Clear	12/06/2016	≤3 months	GBR	4.7/8 mm
2	Woman	53	I	MX	POST	Clear	09/08/2016	≥3 months	Sinus	4.1/8 mm
3	Man	66	III	MX	POST	Clear	11/29/2016	≥3 months	Sinus	3.7/8 mm
4	Man	49	IV	MX	POST	Clear	12/13/2017	≤3 months	None	4.1/10 mm
5	Man	45	III	MX	ANT	Clear	01/19/2018	≤3 months	None	3.7/11.5 mm
6	Woman	51	IV	MX	POST	Clear	04/28/2017	≥3 months	Sinus	4.7/11.5 mm
7	Man	78	III	MX	POST	Treated HTN	04/03/2014	≥3 months	None	4.7/11.5 mm
8	Woman	62	III	MX	POST	smoking	03/12/2019	≥3 months	None	4.7/11.5 mm
9	Woman	42	II	MX	POST	Clear	09/27/2018	≥3 months	None	3.7/10 mm
10	Homme	45	III	MD	POST	RAS	11/13/2014	≥3 months	None	4.7/8 mm
11	Femme	69	IV	MX	POST	RAS	04/21/2016	≥3 months	Sinus	6/8 mm
12	Femme	69	IV	MX	POST	RAS	04/22/2016	≥3 months	Sinus	6/8 mm

Table II. Implant and preimplant surgery activity over the 6 years follow-up.

Year	Implant	Sinus lift	GBR	Loss
2014	62	7	3	2
2015	62	16	24	0
2016	70	14	31	3
2017	67	19	44	2
2018	55	9	16	2
2019	60	7	17	1
Total	376	72	135	12

signs of bone resorption and dehiscence at the implant neck were found in 58% (7/12) and 8.3% (1/12) of patients, respectively.

Failure's characteristics according to length and diameter

All implants were placed by 4 senior practitioners during the 6-year follow-up period. All implants had a cylindrical-conical macrostructure and were placed at bone level.

Failures varied according to implant diameter and length. Most of the failures occurred in 4.7 mm diameter (5/12) and 8 mm length (6/12) implants. Compared to other diameter there is no significative difference ($p = 0.174258$), but there is a significative difference for 8 mm length implants compare to other length ($p = 0.0009$).

Also Tables I and IV shows a higher proportion of failure for 6 mm diameter (8.33%, 2/24) and 8 mm length (13.64%, 6/44) implants. There is no significative difference for 6 mm diameter implants (p= 0.53185).

Topography, bone quality and periodontal status

Failures occurred the most for maxillary implants (10/12) compared to mandibular implants (2/12). Failure was higher in the posterior sectors (11/12) than in the anterior sectors (1/12).

Concerning bone quality, 9 out of 12 failures occurred in stage III/IV bone types (Fig. 1).

Many failures were noted on sites rehabilitated by pre-implant bone surgery. 6 out of 12 of the implants failures happened in grafted bone (5 on grafting by sinus lift and one on GBR) in the posterior sector.

Regarding to pre-implant surgery type, we reach a graft failure rate of (5.64%, $\sigma = 11.43\%$) for sinus lift and (0.54%, $\sigma = 1.32\%$) for GBR.

The bone graft substitute used for all grafts was a biphasic alloplastic material composed of hydroxyapatite and β-tricalcium phosphate.

33% (2/6) of previously treated patient with bone graft presented respectively localized stage 2 and generalized stage 3 periodontitis.

Insufficient keratinized mucosa width (<2 mm) found in 8.33% of cases (1/12) indicate free gingival graft.

Risk factors associated with failure

Among the implant failures, some patients had known risk factors such as active smoking (1/11), rheumatoid arthritis (1/11), high blood pressure (1/11) and surgical site infection (1/11).

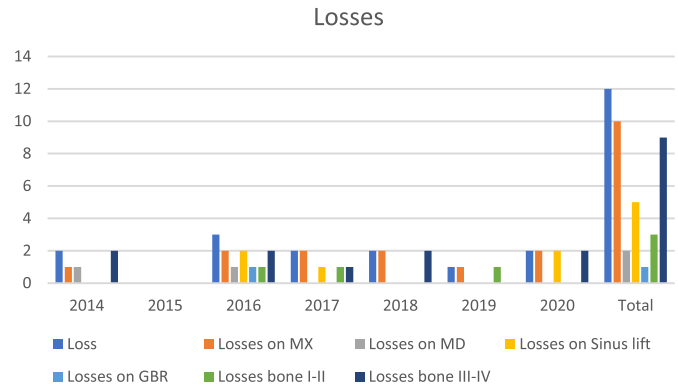

Fig. 1. Losses according to bone type, preimplant surgery and bone localization.

Table III. Clinical signs and types of event associated with failures.

Cases	Event	Clinical signs
Case n°1	Superinfection	inflammation/infection/suppuration
Case n°2	Poor integration	None
Case n°3	Poor and lost of integration	None
Case n°4	No primary stability	Inflammation/Bone loss
Case n°5	Poor and lost of integration	Pain/Bone loss
Case n°6	lost of integration	Discomfort/Bone loss
Case n°7	Implant abutment rupture	Discomfort
Case n°8	Poor integration	None
Case n°9	Poor integration	Discomfort/inflammation/infection/dehiscence/Bone loss
Case n°10	Lost of integration	Pain/infection
Case n°11	Lost of integration	Pain/edema/bone loss
Case n°12	Lost of integration	Pain/edema/bone loss

Table IV. Diameter and length of placed implants.

Diameter	3.1 mm	3.7 mm	4.1 mm	4.7 mm	6 mm	
n	3	135	94	120	24	
Length	6 mm	8 mm	10 mm	11.5 mm	13 mm	16 mm
n	1	44	172	133	25	1

The patient who was a smoker had an estimated consumption of 30 pack-years. Failure associated with rheumatoid arthritis occurred in a woman treated with Naproxen (275 mg: 1-0-0) and paracetamol for crisis in mildly progressive RA. The one failure associated with HBP occurred in a patient treated with Telmisartan/Hydrochlorothiazide (40/12.5 mg : 1-0-0) known as an angiotensin-2 inhibitor associated with a thiazide like diuretic. Finally the surgical site infection was diagnosed in a patient presenting signs of inflammation and infection due a to pus outlet (Tab. IV).

Removal of implants

In the present study, all implants were removed using a trephine bur.

Discussion

The mean age of patients who had implants removed was 55.5 ± 11.5 years; consistent with studies by Lin *et al.* (≥41 years) [10] and Compton *et al.* (62.18 ± 8.6 years) [11].

Furthermore, the literature shows that the most severe complications appear mainly in the oldest subjects [12].

The small number of patients in the study does not allow conclusions to be drawn on parity, there is no significative difference of lost implants among men and women ($p=1$ OR = 0.95). Whereas in the literature, implant failures are twice more frequent among men [10].

Failure rate

The main criterion for implant failure, defined by "implant removal", is standardized, simple, and clinically relevant. This criterion advantage is that it does not lead to interpretation bias between practitioners. This study shows a low failure rate of 3.11% over a 6-years follow-up period. There is no statistically significant difference between our data compared to Castellanos-Cosano's [6], they report a failure rate of 2.1% over 4 years ($p=0.14$) with particularly low rates for grade V titanium, long and large diameter implants. Failure rates differ with a higher percentage for our study (OR = 0.6395). The present study also finds a higher failure rate with short (8 mm) implants ($p=0.0009$), which emphasized the need for good lengthwise anchorage to improve primary stability and to reduce failure risk the first year, as shown by Balevi *et al.* [13]. We also find a higher failure rate for large implants (6 mm) ($p=0.17$), placed in the posterior sectors, they are under heavy stress from powerful occlusal forces [14].

The most frequently encountered complication was peri-implantitis which is characterized by gingival inflammation and bone resorption. This major biological complication is the origin of an annual failure rate of 2.32% over the follow-up period of our study, and it is comparable with that of Papaspyridakos *et al.* [7] (1.6%; $p=0.82$) in spite of a lower rate for our study (OR = 1.17).

Peri-implantitis is a condition that depends on the survival of the implant in each functional situation and not only on the patient [15], but a longer follow-up period would have likely seen an increase in the number of failures due to peri-implantitis. That is why periodontal maintenance before and after surgery is necessary to avoid the loss of osseointegration.

To avoid bacterial complications, peri-implant health as described by Araujo and Lindhe [16] is crucial for implant success. The periodontium is structurally different around an implant compared to a tooth due to the absence of periodontium. It remains more fragile, so the prevention of complications in order to reinforce the periodontal biotype advanced by Lee *et al.* [17] is important. Measurement of gingival thickness and abundance of keratinized tissue is an essential diagnostic and maintenance aid.

Risk factors associated with failure

Topography, bone quality and periodontal status

For 70% of implant failures, the bone was type III or IV, namely a low-density bone. Achieving correct primary stability is a real challenge in these conditions as this type of bone requires suitable preparation by under-drilling and does not allow any widening of the borehole. Over-drilling is a frequent pitfall on low density bone as it offers little resistance. However, some studies show that there is no difference of failure rate between implants placed with high torque compared to those placed with low torque [18]. Cohen *et al.* demonstrated that implants placed with low torque under over drilling conditions increased the bone/implant contact area in the short term [19].

The implant failures in this study were mostly posterior implants what is comparable to several studies [20–22]. This can be due to a combination of several conditions often present in posterior sectors: insufficient bone volume, poor bone quality and excessive occlusal forces [14]. Though Lin *et al.* (2018) [10] suggested that the risk of implant loss is more important in the anterior mandibular sector; their study concerns early loss and not late loss as in the present study.

Ko *et al.* [23] demonstrated that the thickness of the cortical bone decreases in the following directions: posterior mandible, anterior mandible, anterior maxilla, posterior maxilla. This may explain why 83% of the failures found in this study occurred in the maxilla like in Kern *et al.* [24] 5-year follow-up study.

As generalized manifestation, uncontrolled periodontitis has been known to be a risk factor for the development of peri-implant diseases [25] and according to Shatta *et al.* [26], periodontitis declare more likely on implant placed in grafted bone.

Furthermore peri-implant bone loss is influence by local periodontal environment. Mailoa *et al.* [27] found out that implant vertical placement is important, distance >3 mm compared to cemento-enamel junction is at risk of peri-implant bone loss. In other case peri-implant bone loss could be linked with adjacent tooth extraction as demonstrated by Urdaneta *et al.* [28].

Pre-implant surgery

55% (6/12) of the removed implants were placed in grafted bone. Pre-implant bone grafts are a major risk factor of implant loss. Grafted bone using bone graft substitute is of poorer quality than natural bone, and the additional surgical procedures expose the implant to additional complications as reported in a meta-analysis by Lozano-Carrascal *et al.* [29]. They recommend the use of short implants as an alternative treatment to pre-implant sinus lift surgery. For certain indications, these implants offer a success rate close to standard implants. However, the conditions are demanding. Malchiodi *et al.* [30] reports that in the presence of a wide ridge, at least 9 mm is required for the good vascularisation of these short implants. There is a good success rate with a Crown/Implant ratio of 3:1.

Failure rate associated with sinus lift surgery is especially high, reaching 5.64% in our study. This is consistent with a meta-analysis published by Chaware *et al.* [8]. They found a mean failure rate associated with sinus lift of 4.2%. Statistical

analysis showed no significant difference between studies ($p = 0.23$), our study showed a higher rate of failure due to preimplant sinus lift surgery (OR = 0.57). This confirms that others surgical technics and preventive measures [5] should be provided to reduce the overall failure rate.

Lifestyle habits

Active smoking was a risk factor found in 8.3% of failures. This rate is similar (9.4%) to the rate of the Compton *et al.* study (2017) [11]. Studies show that smoking disrupts implant osseointegration according to Noda [31] and is considered a major risk factor according to the meta-analysis done by Hui Chen [32]. The role of tobacco as a risk factor for implant failure remains poorly described. Some authors suggest that smokers treated with dental implants are more exposed to postoperative complications, such as infections and peri-implantitis [33].

Systemic diseases and bone healing

8.3% (1/12) of failures are correlated with osteoarticular pathology. Nagy *et al.* [34] showed in a review of the literature that a person with rheumatoid arthritis reacts more severely to periodontal disease partly due to their treatment. Peri-implant parameters such as gingival bleeding index and marginal bone resorption are more significant in these patients.

Surgical site infection (SSI)

In this study, 8.3% (1/12) of removed implants were removed following a SSI. Infection at the operating site generally compromises the proper osseointegration of the implant. According to Octavi Camp-Font *et al.* [35], only 33.5% of implants with SSI can be retained. Furthermore, authors show that antibiotic therapy alone is ineffective in 89% of cases to treat the SSI, second look of the operative site being indicated in most instances. These results are consistent with the presence of implant failures due to SSI in the present study.

Hypertension

The failure in our patient treated for hypertension is not related to the disease itself, it was an implant abutment rupture (Tab. III). In addition, Micardiplus does not cause side effects such as gingival hypertrophy which could have blocked implant integration [36].

Other risk factors

Lizet Castellanos-Cosano *et al.* [6] found that other risk factors correlated with high failure rates included diabetes mellitus, bruxism and cardiovascular pathologies. These factors were not identified in this study.

If the risk factors are described individually, they may be concomitantly present.

3D positioning and vascularisation

Implant placement is challenging for its durability. In this study all implant were placed to respond to prosthesis, primary stability and peri-implant vascularization. If one or more of these conditions were not present, the use of pre-implant surgery or a reduced size implant or specific shaped implant was necessary to follow what Farronato demonstrates [37]. Peri-implant bone thickness is crucial for good bone and periosteal vascularization of the implant. His study shows that a minimum bone thickness of 1.5 mm around the implant is necessary for good peri-implant tissue durability, otherwise bone loss is inevitable.

Dental implant is also more fragile to bacterial attacks because it does not have a periodontal vascularization as shown by Sadowsky in a cartographic review [38].

All implants were placed without the aid of surgical guides, nevertheless their use allows a greater precision in the positioning of the implants to respect the requirements. Yeung *et al.* [39] found dimensional and angulation displacements in guided implants with clinically acceptable limits in an *in vitro* study.

Removal of implant

Implant removal is a delicate issue when implant failure occurs. The goal is to remove the failed implant without compromising the integrity of the adjacent teeth and periodontium. Among many removal techniques, Alex Solderer *et al.* [40] recommend the use of the "counter-torque technique" for its non-invasiveness, it allows the implant to be unscrewed without contacting adjacent bone. However, this technique is only feasible when osteointegration is not established. In the case of peri-implantitis, a technique using a trephine bur should be used; the use of ratchets can complete the removal after the trephine circular osteotomy is done.

In several new studies, implant removal can be performed using piezosurgery. This technique should be considered for every implant removal since it has a high success rate and few complications as reported by Roy *et al.* [41]. Moreover, Kwon and Pae [42] shows that this recent technology makes it possible to manage particularly complex cases while remaining conservative. The use of piezosurgery was not available in our oral surgery department.

Corrective actions

This study shows that the implant failure rate is greater in low density bone, in the posterior maxillary sector and on sites having undergone bone grafting. These data suggest that implant failure may be reduced by improving implant anchorage by under-drilling and increasing osseointegration time to 6 months before loading as suggested by Manso [43]. In the case of rheumatoid arthritis, the perioperative uptake of NSAIDs couldn't be related to an increase risk of failure according to Chappuis *et al.* [44]. But in more aggressive case of RA, treatments may affect badly the

failure rate. For those patient, the initial periodontal preparation should be complemented by a rheumatologist consult to discuss implant treatment or change of medication [34]. Implants with rough surfaces, aggressive threads and under-drilling allow the implant to be inserted with sufficient torque and good primary retention. A large implant diameter increases the bone/implant contact area but does not improve long-term prognosis compared to standard implants [45]. The use of short implants can be an alternative to sinus augmentation surgery depending on clinical conditions [29]. The second point of improvement for smoking patients is at least a very brief advice to quit smoking, achieved by asking on record smoking status, advise on the best way to quit (medication, specialist) and act according to patient's response (refer or prescribe nicotine replacement therapies).

Conclusion

This retrospective study demonstrates the importance of a thorough medical history, inquiry into lifestyle habits, and a good psychological approach coupled with good clinical and radiological examinations will assessing the relative risks to the bone and to the patient. A good compliance, smoking cessation, a drilling sequence adapted to the bone type and periodontal maintenance are the basics of peri-implantitis prevention and successful implant rehabilitation.

An observational survey conducted prospectively should confirm these data.

Conflict of interest

The authors do not declare any conflict of interest.

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Ethical approval

Ethical approval was not required.

Informed consent

This article does not contain any studies involving human subjects.

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