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A retrospective study on 1592 consecutively performed operations in one private referral clinic. Part I: Early inflammation and early implant failures

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Abstract

Background: Few large-scale follow-up studies are reported on routine implant treatment.

Purpose: To report retrospective data on early inflammatory and early implant failures in a large number of routine patients at one private referral clinic.

Materials and Methods: A total of 1017 patients were consecutively provided with 3082 implants with an anodized surface (Nobel Biocare AB) at 1592 implant operations between 2000 and 2011. All patients reported with mucosa inflammation and bone loss and/or implant failures to the first annual examination were identified. A logistic multivariate data analysis was performed to identify possible factors with an association to the two events.

Results: Altogether 33 patients/operations presented early inflammation (2.1% operations). "History of periodontitis" (OR 3.91; 95% CI: 1.86-8.21), "numbers of implants" (OR1.33; 95% CI:1.07-1.67 per implant), "two stage surgical technique" (OR 3.70; 95% CI: 1.75-7.85), and "lower jaw" treatment (OR 4.73; 95% CI: 2.12-10.57) increased the risk for early mucositis with bone loss ($P < .05$). Highest risk for early inflammation was observed for patients at an age of 50-55 years at surgery ($P < .05$). "Smoking habits" (OR 2.08; 95% CI: 1.06-4.10) "Immediate implant placement" (OR 2.09; 95% CI: 1.23-3.54), and "immediate grafting procedures" (OR 2.09; 95% CI: 1.04-4.19) had a significant association to early implant failures ($P < .05$). Furthermore, risk for an early failure decreased with 22% per year of inclusion (2000 >2011; OR 1.22; 95% CI;1.08-1.39).

Conclusion: History of periodontitis and two-stage surgery protocols with bone grafts in the (posterior) lower jaw increased the risk for early inflammatory problems after surgery ($P < .05$), with the highest risk for mid-aged patients ($P < .05$). Preventable factors related to the patient (smoking) and experience of surgeon showed to have a significant association to early implant failures in routine clinical practice ($P < .05$).

KEYWORDS

complication, efficacy study, effectiveness study, follow-up, immediate placement, implant failure, inflammation, learning curve, mucositis, one-stage surgery, smoking habits, two-stage surgery

1 | INTRODUCTION

Implant treatment can be divided into two major phases where the first phase is to establish a firm and stable osseointegration of the installed implant followed by the second phase where the aim is to maintain osseointegration, implant stability, and tissue health over time during follow-up.[1] Implant failures during the first phase is observed as lose implants which are interpreted to never have integrated and the time interval for these "early failures" are recorded from implant surgery up to a period of implant function.[1,2] This period of time may vary since

radiographs many times are needed to detect these early implant failures. Accordingly, radiographs taken after prosthesis placement has many times been used as the end of this early period, and the length of this time period are dependent on the routines in the specific clinic.[1,2] Implants that are lost at a later time after the first radiographic follow-up examination have then been recorded as "late failures" where the implants are considered to lose osseointegration rather than never have been osseointegrated.[1,2] Thus, the length of the time period for implants at a risk for early failures is much depending on both choice of surgical loading protocol and when the first radiographic follow-up examination has been performed after prosthesis loading in routine practice.[2] However, irrespective of what surgical loading protocol or time for first radiographic examination after prosthesis placement that has been used, still most follow-up studies have indicated that more patients lose more implants during the first, early, phase of treatment as compared to during the second, later, phase of follow-up.[3–8]

Many studies have been published on various aspects related to the risk for early implant failures and complications, and literature reviews have many times been necessary to provide an overview on available clinical evidence. However, these overviews may come to different results as exemplified by the overview on the impact of different loading protocols at surgery. Reviews on different surgical protocols have both reported as there are no obvious differences in early implant failure rates between early and late loading[9] while another overview reported statistical different results between the loading protocols.[10] One obvious difference between the two review studies was that in the first overview only prospective randomized controlled trials (RCT) were included,[9] while also retrospective studies were included in the other one.[10] Accordingly, it can be assumed that when only small, well-controlled prospective studies are included they more reflect the treatment under optimal conditions showing what may be possible to achieve (efficacy study), while larger retrospective studies report more what could be expected under more routine conditions (effectiveness study). Thus, efficacy studies could be expected to present both better results and smaller variations between different treatment options in contrast to effectiveness studies with a less strict control of the treatment protocols. Instead, these effectiveness studies may reflect more what can be expected in "routine practice." Today there is relatively few large, retrospective, studies that can be compared to all published efficacy studies.

The aim of the present study was to report retrospective data on early inflammation and early implant failures at the implants in a large number of patients which have been treated in routine practice at one referral clinic.

2 | MATERIAL AND METHODS

The present study is a retrospective study covering all consecutively treated patients provided with dental implants with an anodized, moderately rough, implant surface (TiUnite, Nobel Biocare AB, Sweden) between March 2000 and December 2011 at one private dental referral clinic (Dr H Antoun, Paris). Patients were scheduled to be followed-up for at least 1 year after prosthesis placement.

Patients had been referred to the clinic for implant surgery by 184 different dentists, and only a few patients were thereafter restored by dentists at the referral clinic (3%). Implant treatment was performed according to three different surgical protocols. Standard protocol at the clinic was to place implants and abutments at one and the same time (one-stage). Immediate placement of the implant into the tooth socket was performed when teeth were removed at implant surgery, predominantly associated with one-stage protocols. Both these protocols could be performed with or without immediate grafting procedures. An alternative two-stage protocol was primarily performed when grafting procedures with guided bone regeneration (GBR) and membranes were used and/or occasionally when optimal clinical stability of the implant was not possible to achieve at implant placement. No specific surgical protocol was used for the upper or the lower jaw.

After implant surgery, the prosthetic treatment and basic follow-up maintenance was performed by the referring dentists outside the referral clinic. However, all patients were invited to participate in a follow-up program including regular clinical examinations and intraoral radiographs at prosthesis placement and then every following year at the clinic. When the patients came to the first visit of the follow-up program, they were included in an automated follow-up program to be recalled on an annual basis or more frequently for patients with a history of periodontal disease. Radiographs were taken on a routine basis at prosthesis placement and then first at the time of the first annual recall, 1 year later. Also, panorama radiographs could occasionally be used during routine follow-up. Furthermore, information was always given that the referral clinic should be contacted whenever a problem was observed at the implants.

Information on treated patients was retrospectively retrieved from all patient files regarding basic data on patients, operations and implants at implant surgery (Table 1). Some of the present patients have a previous "history of periodontitis." The patient had to fulfil three different criteria to be denoted as "having a history of periodontitis"; they should have lost teeth due to periodontitis *and* they should have been treated for periodontitis *and* they should present a stabilized periodontal health, being in maintenance phase, at the time of implant surgery (Table 1).

Recorded events in the present study were inflammatory problems at the implants with bone loss during healing and early loading phase up to first annual examination ("early inflammation"), and failed implants that had been removed up to the first year in function ("early failures"). All patients with obvious signs of inflammation at the implants were referred to the surgeon at the referral clinic. The surgeon made a careful clinical and radiological examination always using intraoral, apical radiographs, and recommended special treatment related to inflammation problems when considered indicated. Only those patients participating in this special program are in the present study referred to as patients with "early inflammation problems." "Early inflammation" was defined as obvious bleeding at probing and/or suppuration in combination with more than one thread of bone loss

TABLE 1 Retrieved baseline parameters tested for significant prediction of risk of early inflammation and failure

1	Age at surgery (year)
2	Cardiovascular disease (yes/no)
4	Gender (male/female)
5	General health (yes/no)
6	History of periodontitis (yes/no)
7	Immediate grafting procedure (yes/no)
8	Immediate mucosal grafting procedure (yes/no)
9	Jaw (upper/lower)
10	Numbers of operations per patient (1 operation/>1 operation)
11	Number of placed implants (one to eight)
12	Number of placed implants (1-3/4-8)
13	Retention of prostheses (cemented/screw retained)
14	Smokers (yes/no)
15	Surgical technique (immediate/one-stage/two-stage)
16	Type of implant (as given in Table 2)
17	Type of jaw (single/partially edentulous/edentulous)
18	Year of surgery (2000–2011)

(>0.6 mm) after implant surgery that was considered to need special attention including reinforced oral maintenance. Extra intraoral apical radiographs, outside the routine, were taken for these patients for diagnosis and treatment purposes.

2.1 | Statistics

Descriptive statistics are presented as numbers, frequencies, percentages, means, and standard deviations. Percentages of patients, operations, and implants with regard to follow-up compliance and no "early implant failures" during the first year in function was calculated according standard survival analysis methods, described by Kaplan and Meijer.[11] Statistical analyses were performed by one bio-statistician regarding two different events; "early inflammation" and "early implant failure." The two events were statistically handled as dichotomous observations, disregarding time when the event was observed from implant surgery to the first annual examination. Available factors which could have a statistical impact on early inflammation and early implant failure (Table 1) were first identified by comparing operations with and without inflammation/implant failure by means of Fisher's univariate permutation test. Identified significant factors were thereafter analyzed by univariate logistic regression followed by a final multivariate logistic regression analysis for "early implant failures" and "early inflammation," respectively.

Nonlinear associations between age at surgery and risk of the two events were studied by a spline logistic regression model. Accordingly, data was fitted using knots at the 10th, 50th, and 90th percentiles of the age of the patient at surgery to study the association between age and risk of implant failure and inflammation within 1 year after surgery in more detail.[12] The splines were second-order functions between the breakpoints and linear functions at the tails resulting in a smooth curve.

Furthermore, Numbers Needed to Treat (NNT) to benefit from using a two-stage surgical protocol with regard to early implant failures was calculated for immediate and one-stage surgical protocols, respectively.

Data was analyzed on "operation level," but a test was performed to compare analysis on "operation level" to tests on "patient level." This test revealed similar statistical results for "patients" as previously observed for "operations". *P* values below 5% were considered as statistical significant.

3 | RESULTS

3.1 | Patients lost to follow-up

It was noticed an increasing number of referred patients during the years of inclusion (Figure 1), but it was also observed that the proportion of noncompliant patients with regard to follow-up increased by time from 2000 to 2011. Even though all patients were invited for follow-up at the clinic after implant surgery, many failed to comply with regard to the follow-up program. Altogether 388 patients (38.2%) were lost to follow-up during the first year after implant surgery and have not shown up for any further control at the present clinic. These patients had been treated with 936 implants (30.4%) at 541 implant operations (33.9%). Cumulative patient follow-up compliance after 1 year was calculated to 80.9% (operations; 83.0%).

3.2 | Patients and treatment

Information on patients, operations, and implants are presented in Figure 1 and Tables 2–4. A total of 1017 patients (605 females) were consecutively treated between March 2000 and December 2011. Mean age of patient at first implant surgery was 54.4 years (SD 13.51), age ranged between 17 and 91 years.

TABLE 2 Distribution of numbers of operations and implants with regard to type of placed implant and time period of placement. Numbers of failures within brackets

Brånemark System® implants	Operations	Implants	Period
Mk III TiUnite	128 (3)	237 (11)	2000–2011
Mk IV TiUnite	89 (4)	187 (4)	2001–2010
Mk III groovy	423 (9)	868 (5)	2001–2011
NobelActive CC	86 (4)	134 (4)	2008–2011
NobelSpeedy groovy	649 (17)	1217 (19)	2003–2011
Nobel Replace Select	215 (4)	437 (7)	2003–2011
Total	1590[a] (41)	3080[b] (50)	2000–2011

[a]Information missing for one operation, and another performed with one NobelDirect implant.

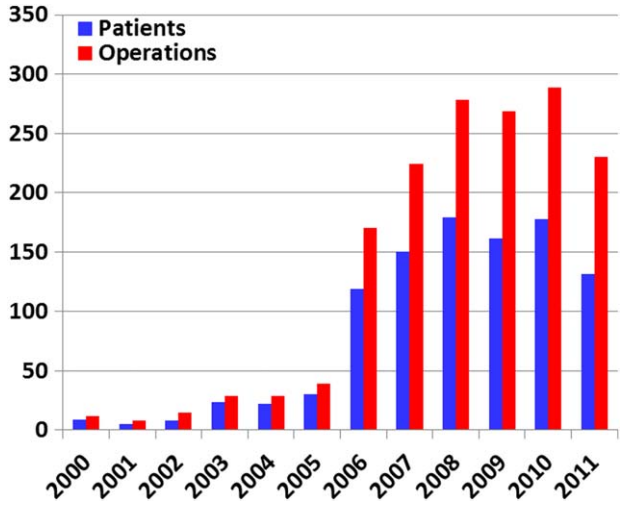

FIGURE 1 Numbers of treated patients and performed operations per year of inclusion

Six hundred and thirty-five patients (62%) reported no general health problems at the time of first implant surgery, and information on smoking habits was available for 963 patients (95%) of whom 181 patients were smokers (19%). Altogether 304 of the patients (30%) had a history of periodontitis at the time of first implant operation.

Included patients were provided with 3082 Brånemark System implants (Nobel Biocare AB, Sweden), all provided with an anodized implant surface (TiUnite, Nobel Biocare). Altogether 1770 and 1312 implants were placed in upper and lower jaws, respectively. Distribution of different types of implants used during the inclusion period is presented in Table 2. Brånemark System Mk III and Mk IV implants were provided with a gradient surface, being less rough at the head of the implant and progressively rougher toward apex.

The implants were placed at 1592 implant operations, where 852 operations were performed in the upper jaw and 739 in the lower jaw (Table 3). Most implants were placed at operations in partially edentulous situations in both upper (*n*-787; 92.4%) and lower (*n*-688; 93.1%) jaws. Remaining 116 operations were performed in edentulous jaws (7.3%).

TABLE 3 Distributions of operations with regard to type of treated jaw. Operations could either be performed in an edentulous jaw (Edentulous); posterior unilateral or bilateral jaw (Posterior); other partially edentulous jaws with more than one implant (Other; >1 implant) or in situations with a single implant (Single)

	Numbers of operations				
		Partially edentulous jaws			
Jaws	Edentulous	Posterior	Other; >1 implant	Single	Total
Upper	65	146	208	433	852
Lower	51	205	109	374	739
Total	116	351	317	807	1591*

*Information missing for one operation.

Implant surgery was performed as a one-stage surgical protocol for the majority of the operations ($n = 1081$; 68%) with remaining operations distributed between immediate placement and two-stage protocols (Table 4). Two-stage surgery was mostly associated with GBR protocol (85%). There was a trend of increasing proportions of surgery performed according to the direct placement protocol, and a reduced proportion of two-stage surgery over time of inclusion from year 2000.

Altogether 784 (49%) operations involved immediate local grafts at implant surgery, predominately using BioOss grafting materials (Geistlich Pharma AG, Switzerland) covered with a membrane during two-stage surgical procedures (Geistlich Bio-Gide, Geistlich Pharma). Altogether 85% and 79% of two-stage and direct placement surgery involved grafting procedures as compared to 33% of the one-stage surgical protocols, respectively.

3.3 | Early inflammation

Early mucosal inflammation with bone loss during healing and the early period in function (≤1year of prosthesis in function) was observed in 33 patients (33 operations; 2.1%). Inflammation was identified in most patients during the last 6-month period of follow-up (Figure 2).

The univariate analyses including also the univariate logistic regression analysis revealed six significant factors regarding differences between operations with as compared to operations with no reported early inflammation; "history of peri-implantitis," "numbers of placed implants," "surgical loading technique" (increasing risk from "immediate to one-stage- to two-stage surgical protocols"), "two stage surgical protocol" (as compared to one-stage and immediate placement surgery), operations performed in "the lower jaw," and when using "MK III groovie implants" ($P < .05$). Other tested parameters (Table 1) did not show any significant difference between operations with and without early inflammation ($P > .05$).

The final logistic multivariate analysis considering dependence between identified parameters showed that "surgical technique (immediate – one-stage -two-stage)" disappeared when "surgical technique (two-stage)" was introduced in the calculation model, indicating that only two-stage surgery is of importance for risk for early inflammation. Furthermore, the parameter related to type of implants (Mk III groovy) also disappeared when "Lower jaw" was introduced, indicating that Mk III groovy implants were unevenly distributed/used between upper and lower jaws. Remaining four factors have a significant association to the risk for early inflammation (Table 5). Overall risk for early inflammation was 2.1%, and the highest risk for early inflammation was due to the logistic regression model at hand when all three identified parameters were contributing and numbers of implants were 7 (45.3%; 95% CI: 18.9-74.6). When none of the parameters were contributing and the number of implants were 1, the risk for early inflammation was only 0.2% (95% CI; 0.1-0.6).

Distribution of the risk for early inflammation in relation to the age at surgery is presented in Figure 3. It can be observed a significant ($P < .05$) nonlinear relationship between risk of early inflammation at the implants after surgery and age at surgery indicating the highest risk for inflammation for mid-aged patients (50-55 years) and lower risks

TABLE 4 Distributions of operations with regard to patient characteristics (periodontitis/smoker) and type of surgery. Surgery could either be performed using an immediate placement, one-stage or two-stage protocol with or without immediate grafting procedure

	Distribution of numbers of operations					
	Patient characteristics		Type of surgical protocol			
Jaw	History of periodontitis	Smoker	Immediate graft	Immediate placement	One-stage surgery	Two-stage surgery
Upper	320	172	524	136	561	188
Lower	236	129	260	103	520	84
Total	556	301	784	239	1081	272

for both younger and older patients ($P < .05$, Figure 3). The statistical risk for early inflammation increases with 8% per year of age ($P < .05$) up to 53 years followed by a decreased risk of 7% per year ($P < .05$).

3.4 | Early implant failures

A total of 50 implants (1.6%) were lost in altogether 41 patients (4.0%) after 41 implant operations (2.6%) from surgery to the first annual examination (Table 2 and Figure 2). Percentage of implants, operations and patients with no reported failure during the first year was calculated to 98.1%, 96.9%, and 95.1% according to standard survival calculation methods, respectively. Most early failures were identified during the first period of time of follow-up early after implant surgery, and none after 7 months in function (Figure 2). Twenty-nine and 12 of the operations with implant failures had been performed in upper and lower jaws, respectively. Altogether 33 (1.9%) and 17 (1.3%) implants were removed in the upper and lower jaw during this early period, respectively. Early implant failures resulted into complete failures of all placed implants in 14 upper (1.6%) and 6 lower jaws (0.8%), most of them provided with one single implant each (17 single implant operations). Remaining complete early failures were observed after placement of two implants in three partially edentulous jaws each (two in lower and one in upper jaws).

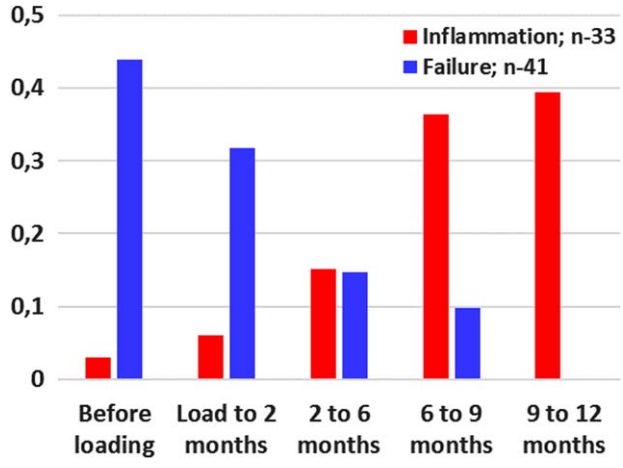

FIGURE 2 Distribution of operations in percentage with regard to time when identified with an early inflammation or an early implant failure (0-1 year in function)

The first univariate analysis (Fishers permutation test) and the following univariate regression analysis revealed four factors with significant differences ($P < .05$) in early implant failures between operations with as compared to without an implant failure; "smoking," "year at surgery" (operations performed early during the inclusion period), "surgical technique," and "immediate grafting technique."

All four identified factors remained significant in the final logistic multivariate analysis ($P < .05$) after considering dependence between identified parameters, all showing a significant association to early implant failure rate (Table 5).

With regard to surgical protocol; 11, 27, and 3 operations using immediate placement/loading (4.6% operations/2.4% implants), one-stage (2.5% operations/1.6% implants) or two-stage (1.1% operations/0.6% implants) protocols were associated with early implant failures. Distribution of early failures between different surgical protocols was accordingly significant for the total group of operations (Figure 4; $P < .05$). Numbers Needed to Treat (NNT) to benefit from a two-stage surgical protocol compared to immediate placement or one-stage surgery was 33 and 72 operations, respectively.

Overall risk for early implant failure was 2.6%, and the highest risk for early implant failure was due to the logistic regression model at hand when all three identified factors contributed and year of surgery was 2000 (36.5%, 95% CI: 14.6-65.8). The second highest risk for early failure was the same situation but without immediate grafting (21.6%, 95% CI: 6.7-51.2), while the lowest risk was at hand when none of the factors were present and year of surgery was 2010 (0.4%, 95% CI: 0.2-1.0).

Distribution of the risk for early implant failure in relation to the age at surgery indicated a decreased risk of failures at higher age, however, not reaching a significant level ($P > .05$).

4 | DISCUSSION

In contrast to small, well controlled, prospective efficacy studies, large retrospective effectiveness studies are performed under different conditions. Since effectiveness studies aim for reporting treatment under normal routine conditions they should be designed with as low risk as possible for impact from the observations per se. Accordingly, these studies must much rely on the structure of the basic protocols and compliance to these protocols in the clinic which is a challenge when including hundreds of dentists and thousands of patients/operations

TABLE 5 Final multivariate logistic regression analyses on identified significant parameters related to "*early inflammation*" and "*early implant failures*"

Significant parameters for "early inflammation"	OR	95% CI	Comments based on the other three factors are kept unchanged
History of Periodontitis $P < .001$	**3.91**	**1.86-8.21**	Higher risk for history of periodontitis
Lower jaw $P < .001$	**4.73**	**2.12-10.57**	Higher risk in the lower jaw
Number of implants $P = .011$	**1.33**	**1.07-1.67**	Increased risk with increased numbers of implants
Surgical technique, two-stage $P < .001$	**3.70**	**1.75-7.85**	Higher risk for two-stage versus one-stage and immediate placement
Significant parameters for "early implant failure"			
	OR	**95% CI**	**Comments based on the other three factors are kept unchanged**
Smoking habit $P = .033$	**2.08**	**1.06-4.10**	Higher risk for smokers
Year of surgery $P = .0016$	**1.22**	**1.08-1.39**	Risk for early failure is reduced by 22% per year of inclusion
Immediate grafting $P = .039$	**2.09**	**1.04-4.19**	Higher risk for immediate grafting procedures
Surgical technique $P = .0065$	**2.09**	**1.23-3.54**	Higher risk for one-stage surgery and even higher for immediate placement protocol

over several years' period of time. One such consistent basic protocol during the years was the first annual radiographic examination which has been used as an end point for identifying early implant failures. A risk for a minor over-evaluation of the early failures could here be considered, but no implant failure was observed after 7 months.[2]

Furthermore, when using this study design, it is important to report how patients are included into the study with regard to different aspects over time (Figure 1), but also to report how the patient later comply and show-up for follow-up examinations at the referral clinic. Even though all patients were invited to attend annual examinations at the present referral clinic, not all patients showed up. This could be due to that the patients did not appreciate the treatment at the clinic or that patients without any symptoms or complications could refrain from this examination, saving both time and money. Accordingly, it could be suggested that patients with problems may show-up more frequently at the surgical referral clinic compared to those without problems, suggesting a risk for over-representation of complication patients during early follow-up. Thus, in the light of the design of the present effectiveness study, it could be suggested that nonsatisfied patients or patients without problems may prefer to stay with their restorative dentist while patients with early implant problems may be more often referred back to the referral clinic to be handled by the surgeon.

Accordingly, it could be expected a higher number of noncompliant patients during follow-up in an effectiveness study with many referral dentists as compared to small efficacy studies where the controls per se are important parts of the study protocol. In a recent effectiveness study it was reported that 81% of 4716 included patients in two different age groups answered a questionnaire,[13] while only 66% of 900 selected patients in this group showed up for a later actual clinical examination.[14] In another effectiveness study where altogether 184

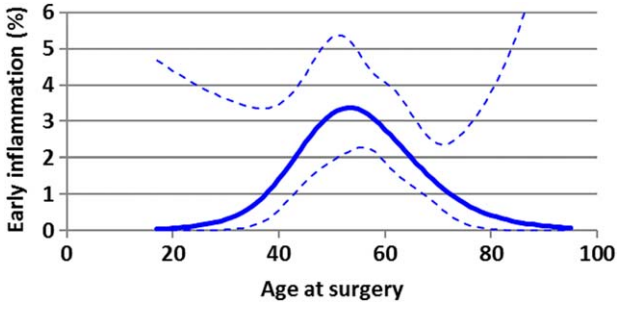

FIGURE 3 Distribution of risk for early inflammation in relation to age at surgery. Maximal risk for early inflammation is calculated at a mean age of 53 years (3.4%, 95% CI: 2.2-5.3) with significantly lower risk for younger and older patients ($P < .05$). Dotted lines indicate 95% confidence intervals

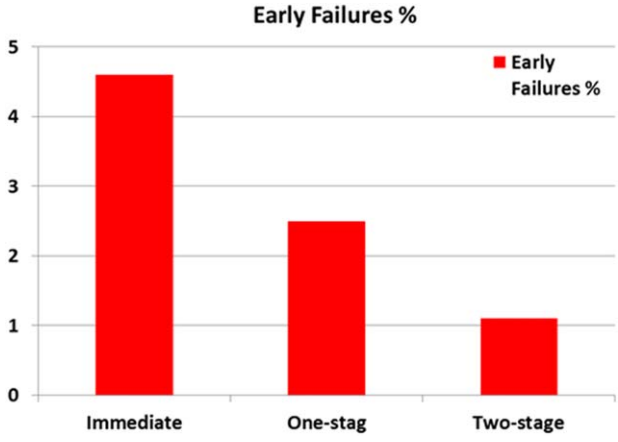

FIGURE 4 Distribution of operations (%) with early implant failures with regard to different surgical loading protocols. Differences between surgical protocols were statistically different ($P < .05$)

patients were retrospectively included into a study group, based on earlier taken radiographs showing "progressive bone loss,"[15] only 46% of them showed up later for a clinical examination to examine the health of the peri-implant mucosa.[16,17] In the present study altogether 66% of the patients were followed-up for **1** year at the clinic (81% according to life table calculations). This is comparable with observations form earlier discussed effectiveness studies,[13–16] but lower as compared to another effectiveness study where most patients were prosthetically restored at one and the same clinic (90%).[18] Thus, present patient follow-up is comparable with other larger retrospective effectiveness studies and the risk of underscoring more obvious complications as early implant failures and more severe early inflammation due to patients lost to follow-up is judged to be relatively low.

The two endpoints used in the present study ("early inflammation" and "early implant failure") are both statistically analyzed as dichotomous parameters, disregarding the time of the event during the period from surgery to the first annual examination. However, it can be noticed that early implant failures are reported after a short period of time after surgery (Figure 2), suggesting that these failures basically only represent failures where the implants never have integrated.[1,2] Many of these early implant failures are associated to preventable factors related to the patient (smoking habits) and surgical technique (experience and choice of surgical loading technique), accordingly closely related to the patients and the surgeon per se (Table 5). On the other hand, "early inflammation" is reported at an increasingly later time period after implant surgery (Figure 2), suggesting it may take some time to build up sufficient inflammation and bone loss that eventually initiate a clinical diagnosis and special clinical attention. It can be noticed that smoking habits are not associated with "early inflammation" but history of periodontitis (Table 5). Since there are no statistical associations between the present two endpoints and they show different patterns of time of report, it could be suggested that they may be associated to two different inflammatory responses in the tissue.

Young patients in the adolescence are missing teeth much due to partial anodontia or trauma which are not caused by any inflammatory processes, and tooth loss due to an inflammation driven periodontitis will in most situations be observed first later in life. It can be assumed that patients losing many teeth early may suffer from a more aggressive inflammation than those that lose (fewer) teeth at a higher age. In the present study, patients with a history of periodontitis and of an age of 50-55 years at implant surgery present the highest risk for early inflammation after implant treatment (Table 5, Figure 3). It has previously been reported a significant relationship between early implant failures, patient mortality and age at surgery in another large-scale implant effectiveness studies, suggesting a possible systemic association between implants and general health.[2,9,19] Daubert et al.[20] did not specify age distribution in their study, but reported also an association between young age and higher risk for later observed peri-implantitis problems, in accordance with the present observation for early observed inflammation (Figure 3). In two large-scale meta-analyses it has been shown a causal relationship between genetic variations in the inflammatory system and individual risk for coronary heart disease.[21,22] A similar relationship could be suggested here where patients with an increased disposition for an earlier and stronger inflammatory response in the tissues in the oral cavity may suffer earlier and more often from periodontitis inflammation and early tooth loss than others.[2] The mid-aged implant patients (Figure 3) with a history of periodontitis and higher risk for early inflammation (Table 5) have earlier shown a higher risk of inflammation[7] and mortality[2,19] in another population. This may possibly indicate an association between a disposition for a stronger inflammatory response in the oral cavity and general health, reflected as increased risk of earlier mortality.[2,7,19]

Theoretically, early implant failures could be related to several different major factors as; various external impact factors, patient host response factors, surgical and restorative procedures, and implant component characteristics.[1,6,8] In a strict literature review on various dental implants, only referring to randomized controlled studies, it was not revealed any significant differences in failure rates between implant materials, implant shape, implant surface, or implant system.[9,23] However comparisons between turned and roughened implant surfaces indicated higher failure rates for turned surfaces,[9] which is supported by recent larger effectiveness studies.[7,8] In the present study only one surface has been used (TiUnite) with different shapes and design of the implants (Table 2). Even though also two modifications of the surface were used in the present study (gradient and nongradient), no significant difference in early failure rates could be observed which is in accordance with earlier review.[23] However, the early univariate statistical observation in the present study indicated more problems for one implant which disappeared after a further multivariate analysis. This is a strong indication for the complexity of the interaction between biology and different implant components, and results should be approached with caution in large effectiveness studies. Thus, even though moderately rough implant surfaces probably will reduce the risk for early implant failures,[7,8] still there are no evidence that any other different implant components have any impact on early inflammation or early implant failures, in accordance with others.[23]

All implants in the present study were placed by one and the same surgeon throughout the entire inclusion period, while basically all patients were finally restored by dentists outside the clinic (97%). It could be expected that variations in surgical performance will be lower when only one surgeon is placing all implants.[24,25] However, this clinical set-up limits informal discussions on a daily basis between surgeons as well as introduction and guidance by more experienced surgeons into new surgical protocols as can be performed in clinics with more surgeons.[25] Instead, single surgeons must learn and build up much of their clinical experience by themselves which may lead to a more obvious clinical learning curve than otherwise could be observed. Even though the present surgeon had clinical experience from dental implants from the early 1990s, new implants, new grafting materials and new surgical techniques have been tested in new clinical situations during the years. This continuous learning can here be observed in the present results related to years of clinical experience (Table 5; "year of surgery"), also observed for some but not all surgeons in one and the same clinic.[25] Thus, decreasing early failure rate by time is probably not

only related to improved surgical protocols, improved implants or for example, reduced use of tobacco in the population, but also related to increased surgical experience. This may be interpreted as that the risk for failures and complications may increase any time when any well-established protocol is changed, introducing a new period of learning, also for the very experienced surgeon.

It was for many years considered that a two-stage surgical procedure with delayed loading was the safest and most predictable clinical protocol for establishing osseointegration.[3–6] However, studies were conducted already in the late 1980s to test alternative protocols comparing for example, one- and two-stage protocols.[26,27] Most of the predominantly small prospective studies that were performed to test these different protocols failed to show any statistically significant difference between chosen surgical techniques,[9] thereby interpreted by some clinicians as being protocols with the same risk. However, the results were not completely consistent and surgical protocols showed different success rates when also including retrospective studies as well.[10] In the present large scale, retrospective, effectiveness study there is a consistently increasing risk for early implant failures from two-stage surgery to one-stage and immediate placement (Figure 4, Table 5), in agreement with earlier report.[10] However, it is important to remember that large-scale studies covering hundreds of patients/operations may more easily show statistically significant differences than studies based on fewer patients. Thus, information on the magnitude of the difference between the two techniques is important to consider, and the differences in failure rate here is indicated to be some few percentages between immediate placement and two-stage protocols (Figure 4). Numbers needed to treat (NNT) to benefit from the lower risk of failure using two-stage surgery can here be estimated to 33 and 72 operations as compared to immediate placement and one-stage surgical protocols, respectively. These numbers should be evaluated in relation to the patient and clinical advantages to use immediate/one-stage procedure as a routine clinical protocol.

Smoking habits was one of four parameters that showed to have a statistical significant impact on early implant failures (Table 5). Smoking is one of the most established risk factors in medicine and is the major cause of death that can be prevented in western societies.[28] Furthermore, smoking is a well-established risk factor also in implant dentistry in accordance with other observations.[29–32] The impact of smoking could be associated with patient life style and oral maintenance and/or local impact on plaque formation as well as a systemic impact on the biological host response in the implant site.[28–32] Since establishment of osseointegration take place early, many times underneath the mucosa in the bone tissue, it could be suggested that the interaction between smoking and more systemic biological host response factors may play an important role for these early implant failures.[32]

Two-stage surgical protocols and surgery in the lower jaw are two other factors with significant impact on risk for early inflammation at the implants (Table 5). This observation could be associated to grafting procedure using GBR technique which was here a frequently used procedure in combination with two-stage operations, especially performed in the posterior part of the lower jaw. Accordingly, grafting procedures associated with membranes may increase the risk for early inflammation at the implants. However, this does not necessarily mean that grafting *cause* early inflammation, it could also mean that patients that present more bone loss and *needs* grafting present a higher risk than others to respond with inflammation after implant treatment. The observation of an association between grafting procedures and higher risk for early inflammation has not been reported earlier and have to be further investigated.

In summary, four different factors have shown to have a significant impact on the risk for early implant failures, all preventable provided smoking habits are reduced and surgeons become more experienced and adjust attitude and surgical protocol to risk of failures. Early inflammation is also associated to preventable risk factors as when choosing surgical technique in the lower jaw, sometimes maybe being more selective when doing and when refraining from surgery in certain situations. Implant treatment of the mid-aged patients with a history of periodontitis must be performed with an awareness of an increased risk for early inflammatory problems, possibly due to that these patients have a systemically driven increased tendency for a stronger inflammatory response than others.

5 | CONCLUSIONS

Within the limitations of this large retrospective effectiveness study based on 1017 consecutively treated patients provided with 3082 implants with an anodized surface at 1592 implant operations, the following conclusions could be made for routine clinical treatment up to the first year in function:

"Early implant failures" are reported during the early part of the time period of follow-up from surgery while "early inflammation" is reported in the later part of the period. The two complications were not associated to each other with regard to included parameters.

Factors related to "smoking habits," "surgical implant loading protocol," "immediate grafting procedures," and "surgical experience" have a significant impact on increased risk for early implant failures in routine practice ($P < .05$).

The risk for early implant failures decreased with about 20% per year of surgical experience from year 2000 to 2011 ($P < .05$).

Factors related to "history of periodontitis," "numbers of implants," "treatment in (posterior) lower jaws," and "two-stage surgical protocols" have a significant impact on the risk for early inflammation after surgery ($P < .05$). A majority of two-stage surgical loading protocols were used in combination with GBR grafting techniques (85%).

Mid-aged patients (50-55 years) who are treated with implants could be considered as a potential risk group for early inflammatory complications after implant treatment ($P < .05$).

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