Incidence of Surgery Related to Problems with Peri-Implantitis: A Retrospective Study on Patients Followed Up between 2003 and 2010 at One Specialist Clinic

Torsten Jemt, DDS, OdontDr/PhD;[*,†] Victoria Gyzander, RHD;[‡] Anna Örnhall Britse, DDS[§]

ABSTRACT

Background: Little knowledge is available on *incidence* of patients treated for peri-implantitis problems in routine follow-up protocols.

Purpose: The aim was to report the incidence, and clinical and radiographic characteristics related to routine follow-up patients who are surgically treated for peri-implantitis problems during 8 years of inclusion.

Materials and Methods: Patients with a history of peri-implantitis surgery were identified from patients examined on routine basis at one clinic (Brånemark clinic) between January 2003 and December 2010. Data on included patients were retrospectively retrieved and reported from dental records and radiographs.

Results: On an average, 1,294 patients per year (SD 96) were followed up during inclusion period. Altogether, 134 patients had surgery related to peri-implantitis problems, corresponding to an average of 1.2% of followed-up patients per year. No prosthesis was completely lost, but altogether, 37 implants (6% of included implants) were removed in 34 patients (25%) during these surgical interventions. Peri-implantitis surgery was observed more often in the edentulous upper jaw ($p < .05$), and there was a tendency that surgery increased by time of follow-up. No significant differences were found between patients provided with machined or medium–rough implant surfaces.

Conclusions: Incidence of peri-implantitis surgery was on an average 1.2% of followed-up patients per year during an 8 years period of inclusion. As no data were available on patient compliance, it could be assumed that the result may underscore the clinical need. Significantly, more edentulous upper jaws were included compared with other treated jaw situations. Data also indicated that the need for surgery may increase by time of follow-up, but no significant differences were observed between patients provided with machined and medium–rough implant surfaces.

KEY WORDS: bone loss, complication, dental implants, failures, follow-up, incidence, peri-implantitis, prevalence, surgery

INTRODUCTION

Surgical placement of dental implants induces on a histological level a foreign body response which is characterized by a chronic inflammation with presence of foreign body giant cells and encapsulation of the dental implant.[1,2] When clinically successful, the body responds with a bone encapsulation of the implant, coined by Brånemark as *osseointegration*,[3,4] while a fibrous encapsulation is a clinical criterion for a failure. With an adequate further biological response, long-term clinical follow-up studies have reported very good clinical success for the osseointegrated implants.[5–15] However, occasionally, the biological balance is lost, and obvious

*Professor, Department of Prosthetic Dentistry/Dental Material Science, Institute of Odontology, Sahlgrenska Academy at Göteborg University, Göteborg, Sweden; †prosthodontist, Brånemark Clinic, Public Dental Health Service, Region of Västra Götaland, Sweden; ‡oral hygienist, Brånemark Clinic, Public Dental Health Service, Region of Västra Götaland, Sweden; §periodontist, Brånemark Clinic, Public Dental Health Service, Region of Västra Götaland, Sweden

Reprint requests: Dr. Torsten Jemt, Brånemarkkliniken, Medicnaregatan 12C, 413 90 Göteborg, Sweden; e-mail: torsten.jemt@vgregion.se

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clinical signs of mucosal inflammation and progressive bone loss can be observed at the implants during follow-up. This situation is referred to as *peri-implantitis*,[16] and different research teams have tried to identify the prevalence of this problem in the implant population.[17–21] Obvious variations in prevalence among the different study groups have been reported.[17–21] It is reasonable to assume that this difference in prevalence to some extent is due to various definitions of the problem,[21] using different clinical and radiological criteria for inclusion. However, the ultimate situation for the patient with peri-implantitis problems must be when the problem becomes so severe that a surgical intervention is indicated to try to restore the biological balance and to maintain the longevity of the implant prosthesis. Accordingly, even though indications for peri-implantitis surgery as well as patient compliance may vary over time, this intervention could be a clear and well-defined end point for identifying the most severe peri-implantitis situations in a population.

The aim of the present retrospective study was to report the incidence of peri-implantitis surgery over an 8 years period in one specialist clinic, and to analyze these interventions to time of follow-up, type of treated jaw, and implant surface.

MATERIALS AND METHODS

In brief, the present study is a *retro-prospective* cohort study,[22] covering all consecutive patients, surgically treated with problems related to peri-implantitis at one specialist clinic (Brånemark Clinic, Specialist Dental Division, Public Dental Health Service, Region of Västra Götaland, Sweden) between 2003 and 2010.

Clinical and Radiographic Procedures

Edentulous and partially edentulous patients were treated with implants on a routine basis in the clinic since the start in January 1986. Up to December 2010, preliminary data indicate that a total of 9,279 implant placement surgeries were performed, covering 36,523 implants at the clinic (Figure 1 and Table 1).[23]

A two-stage surgical protocol was used on a routine basis for most patients during the years.[24] However, a one-stage surgery protocol was introduced at the clinic for lower jaws, starting during the period of 2002 to 2004.[25] Mainly Brånemark System® implants (Nobel Biocare AB, Gothenburg, Sweden) with a machined or a medium–rough surface (TiUnite®) were placed

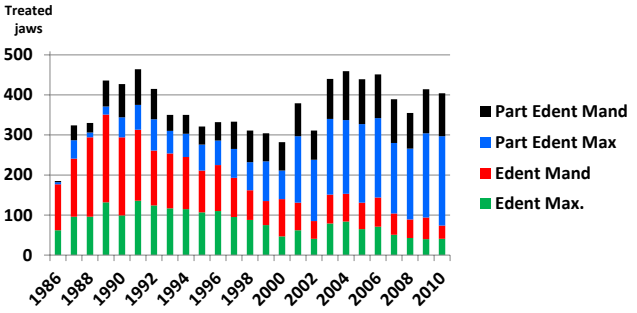

Figure 1 Distribution of treated jaws at the clinic during 25 years (1986–2010).[23]

(Table 1). Replace System® implants with a TiUnite surface from the same company (Nobel Biocare AB) were also used in a limited number. Furthermore, Astra Tech Implant System™ implants (Osseospeed™, medium–rough surface; Astra Tech AB, Mölndal, Sweden) and Lifecore Restore™ implants (resorbable blast media [RBM] surface, medium–rough surface; Lifecore Biomedical Inc., Chaska, MN, USA) were placed in a limited number at the clinic (Table 1). After implant placement, basically, all patients were restored with fixed screw-retained prostheses, connected to abutments.[5,10,13,25–30] The prostheses were designed with a metal framework in cast gold alloy or in titanium, supporting prefabricated resin teeth or porcelain.[10,25–30]

Most treated patients were referred from general dentists, responsible for follow-up and maintenance of the patients after implant treatment. However, as presented in earlier follow-up studies,[26] all treated patients were invited to participate in a clinical and radiographic follow-up program after 1, 5, and then every 5 years in function. Total number of patients followed up at the clinic was compiled and reported on an annual basis during the period (1986–2010), here denoted as *follow-up examinations*.

Intraoral apical radiographs were taken for edentulous patients at the Radiological specialist clinic (Public Dental Health Service, Gothenburg), while partially edentulous patients were mostly radiographically examined at the Brånemark clinic. Examinations were scheduled at the time of prosthesis insertion, and after 1, 5, and then every following 5 years in function.[26] Radiographs were taken at closer intervals when considered indicated.

Study Group

Most patients were recalled and examined by the restorative dentists at the clinic during follow-up, and when

TABLE 1 Distribution of Total Numbers of Jaws (Patients) and Implants Treated at the Brånemark Clinic from 1986 to 2010.[23] Distribution of Treated Jaws and Implants in Relation to "Type of Jaw" Is Given within Brackets (%)

	Brånemark Machined		Brånemark TiUnite		Replace TiUnite		Astra Tech Osseospeed		LifeCore RBM Surface		Total	
Type of Jaw	Jaws	Implants	Jaws	Implants	Jaws	Implants	Jaws	Implants	Jaws	Implants	Jaws	Implants
Edent. maxilla	1607	9376	454	2495	10	53	5	27	0	0	2076	11951
	(77)	(78)	(22)	(21)	(0)	(0)	(0)	(0)				
Edent. mandible	2139	10849	404	1684	11	50	1	2	33	134	2588	12719
	(83)	(86)	(16)	(13)	(0)	(0)	(0)	(0)	(1)	(1)		
Part. ed. maxilla	1163	3433	1480	2924	37	58	58	110	0	0	2738	6525
	(42)	(53)	(54)	(45)	(1)	(1)	(2)	(2)				
Part. ed. mandible	1035	3436	795	1814	11	24	33	73	3	5	1877	5328
	(55)	(64)	(42)	(34)	(1)	(0)	(1)	(1)	(0)	(0)		
Total	5944	27094	3133	8893	69	185	97	212	36	139	9279	36523
	(64)	(74)	(34)	(24)	(1)	(1)	(1)	(1)	(0)	(0)		

RBM, resorbable blast media.

considered indicated, referred to the periodontists/oral surgeons at the clinic for assessment and treatment of peri-implantitis problems. The criteria for referral were basically following earlier protocols of handling of periodontitis patients with small individual variations in criteria for referral between the restorative dentists during the inclusion period. After referral to the periodontists/oral surgeon, patients were examined for risk assessment and thereafter treated by oral hygienists. The retrievability of the screw-retained prostheses was frequently used during this phase to facilitate the treatment and also to reduce the need for surgical interventions.

After oral hygienist treatment, an individual assessment was made for either a continuous maintenance program with or without a surgical intervention. Data is not available on patient compliance regarding how many patients that declined a proposal for a surgical intervention.

All surgical interventions at the clinic were consecutively recorded on a routine basis in separate files since January 1986. Accordingly, the present patients were included first after they had been surgically treated for peri-implantitis problems. The patients that were surgically treated for any type of inflammatory reaction related to the implants between January 2003 and December 2010 were collected from the total group of patients in the clinic. This inclusion was performed by finding patients in lists where all surgical interventions at the clinic were consecutively recorded. Patients were identified from the key word *inflammation* where surgical interventions associated with *peri-implantitis*, *mucosa inflammation*, *fistula*, *mucosa hyperplasia*, *bone loss*, and similar problems were retrieved from the lists for 8 consecutive years. As more cases than only related to peri-implantitis surgery were listed, patients were excluded because of reasons given in Table 2, leaving only first surgical interventions related to obvious mucosal inflammation (bleeding on probing and/or pus) combined with obvious signs of bone loss (≥1.8 mm) after at least 1 year of implant function.

Collected Data

Data were retrospectively retrieved from included patient files related to the patients, implant treatment, and the peri-implantitis surgical intervention such as age, gender, general health, smoking habits, numbers and type of implants, time of implant placement, and

TABLE 2 Number of Patients Excluded from Inclusion

Reason for Exclusion	Patients
Implants not placed at the clinic	18
Not implant related surgery	42
Prostheses placed within 1 year	31
Surgical removal of implants only	5
Surgery related to esthetics	4
Technical problems (loose/fractured)	13
Mucositis – no/small bone loss	12
Experimental implant patient	1
Technical (loose screws, cement)	2
Other	2
Total	130

time of peri-implantitis surgery. All available radiographs were also collected, and bone levels were measured in relation to the implant/abutment junction. A mean marginal bone level was calculated for each implant based on the mesial and distal measurement.

Implants that were to be surgically treated because of peri-implantitis (*affected*) were identified in the files. Implants not associated with inflammation and/or progressive bone loss were referred to as *unaffected* in the present study.

Reference Patient Data

Selected publications with representative patients groups at the clinic were compiled to establish a *reference group* to gain information on distribution of numbers of deceased and noncompliant patients during follow-up at the clinic.[10,12,13,26,28–34] This group comprised 1,066 individual patients.

Another reference group was also compiled to allow comparisons of bone levels in consecutive groups of *normal* implant patients after 10 years of follow-up.[10,12,13,31,32,34] This group comprised 315 individual patients after 10 years.

Statistics

Chi-square tests were used for comparisons regarding gender distribution between the study group and the reference groups, and between proportions of different types of treated jaws. Overall statistical significance was set to 5% ($p < .05$) with the patient as the independent statistical observation.

RESULTS

Reference Group (Patients Lost to Follow-Up)

The compiled reference group comprised of 1,066 originally treated patients at the clinic (49.7% females), representing individual patient cohorts from 11 follow-up studies at the clinic.[10,12,13,26,28–34]

Regarding the distribution of noncompliant and deceased patients during the different periods of follow-up, it could be observed that mean percentage of lost patients to follow-up increased from an average of 6% after 1 year to 61% after 15 years of follow-up (Figure 2).

Numbers of Followed-Up Patients at the Clinic ("Population")

Distribution of patients followed up according to routine protocols ranged from 1,134 to 1,462 patients per year (*follow-up examinations*) during the inclusion period (Figure 3). Mean number of examined patients was 1,294 (SD 96.2) during 8 years of inclusion.

Study Group ("Peri-Implantitis Surgery Patients")

Altogether, 264 individual patients were identified with problems related to *inflammation* from the surgical logbooks, where 130 patients were excluded due to reasons given in Table 2.

The remaining 134 patients (137 jaws) were included in the present study group, surgically treated with peri-implantitis–related inflammation problems, more than 1 year after prosthesis placement (Figure 3). Significantly, more women ($n = 91$) than men ($n = 43$) were included in the study group ($p < .05$).

Mean age at implant placement surgery and at first peri-implantitis surgery was 59.1 (SD 11.39) and 68.3

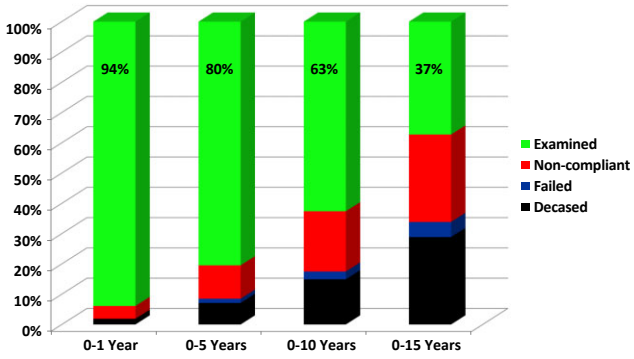

Figure 2 Distribution of examined (percentage) and lost to follow-up patients, based on compiled data in the reference group.[10,12,13,26,28–34]

	2003	2004	2005	2006	2007	2008	2009	2010	Total/Mean
Included	11	5	17	12	32	22	15	20	134
Incidence	0.8%	0.4%	1.3%	0.9%	2.4%	1.7%	1.3%	1.7%	**1.2%**

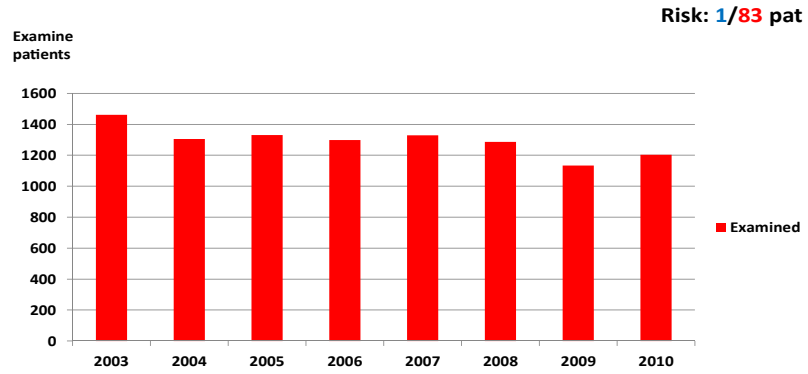

Figure 3 Distribution of included patients during 2003 to 2010 in relation to examined patients per year (incidence).

(SD 11.62) years, respectively. Mean time from first implant surgery to first peri-implantitis surgery was 9.2 (SD 5.54) years (range 2–23 years).

Treatment and Incidence of Peri-Implantitis Surgery (Study Group)

Distributions of included patients (jaws) and implants are presented in Table 3. Altogether, 439 implants (92 jaws) were provided with machined surfaces (Brånemark Implant System), followed up on an average 11.5 (SD 5.15) years, and 174 implants (45 jaws) were provided with medium–rough surfaces (TiUnite/Osseospeed/RBM surface), followed up on an average 4.4 (SD 1.66) years after implant placement surgery, respectively.

The incidence of peri-implantitis–related surgery during the inclusion period in relation to numbers of examined patients of follow-up ranged from 0.4% to 2.4%, with an overall mean incidence of 1.2% over the 8 years inclusion period (Figure 3).

Incidence of peri-implantitis–related surgery per year in relation to numbers of treated patients at time of implant placement surgery (Figure 4; 1986 to 2009) ranged from 0.0% to 3.5% (mean incidence 1.5% [SD 1.04%]).

Distribution of patients with regard to type of treated jaws and time of peri-implantitis surgery in relation to implant placement surgery is presented in Figure 5. Treatment of edentulous upper jaws presented a significantly higher risk for peri-implantitis surgery than other types of treated jaws (Table 3) when calculating the risk on total number of included (study group) and treated patients in the clinic ($p < .05$).

Mean incidence of surgery related to peri-implantitis for patients provided with implants with machined or medium–rough surfaces is presented in

TABLE 3 Distribution of Jaws and Implants in the Study Group. Percentage of Jaws with Peri-Implantitis Surgery Was Calculated in Relation to Total Numbers of Treated Jaws during 25 Years

	Number of Implants in the Jaw								Total		
Type of Treated Jaw	1	2	3	4	5	6	7	8	Jaws	Implants	Percentage
Edentulous maxilla				1	5	27	5	7	45	282	2.38%†
Edentulous mandible		1		5	23	4			33	161	1.31%
Part. edentulous maxilla	6	7	12	5	3				33	91	1.22%
Part. edentulous mandible	2	5	13	3	1	2			26	80	1.40%
Total	8	13	25	14	32	33	5	7	137*	614	1.53%

*Two patients were treated in both the edentulous upper and lower jaws, and one patient was treated in both the partially upper and lower jaw.
†The percentage of peri-implantitis surgery was significantly higher for edentulous maxillae ($p < .05$).

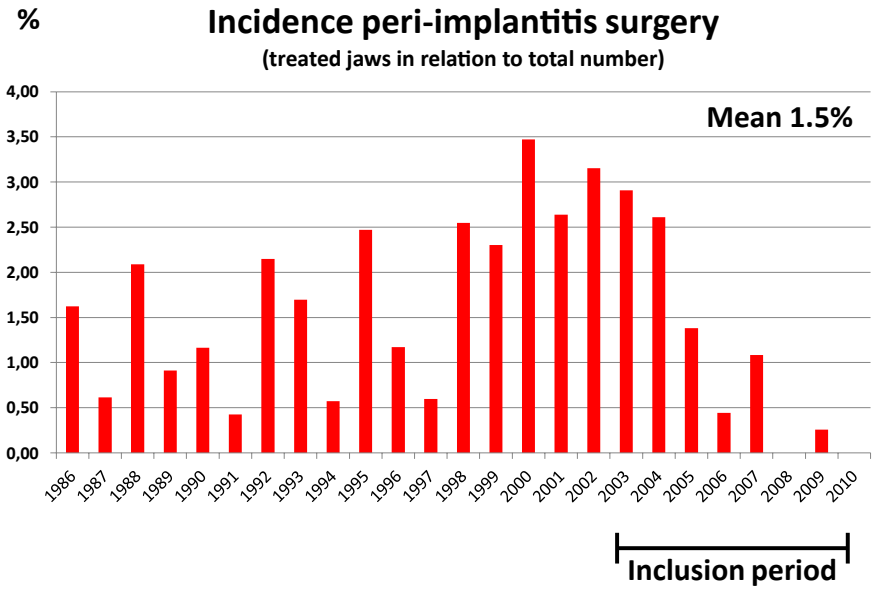

Figure 4 Distribution of incidence of peri-implantitis surgery-treated patients related to year of first implant surgery and total numbers of treated patients during this year.

Figure 6. A slightly higher mean incidence (overall mean 0.30%; range 0.04%–0.52% per year) could be observed for medium–rough implant surfaces for comparable follow-up periods.

Distribution of jaws with regard to numbers of *affected* implants is presented in Figure 7. It can be noticed that 69% of included jaws involved only one or two *affected* implants each. Proportion of jaws including *only affected* implants was lowest for edentulous lower jaws (3%) and highest for partially edentulous upper jaws (48%), respectively. The lowest proportion of *affected* implants in relation to *total numbers* of placed implants was also observed in the edentulous lower jaw (37%). No complete prosthesis failure was observed as a result of implant removal during peri-implantitis surgery.

Radiographic Observations

Altogether, 577 of 614 originally placed implants were available for radiographic evaluation at inclusion

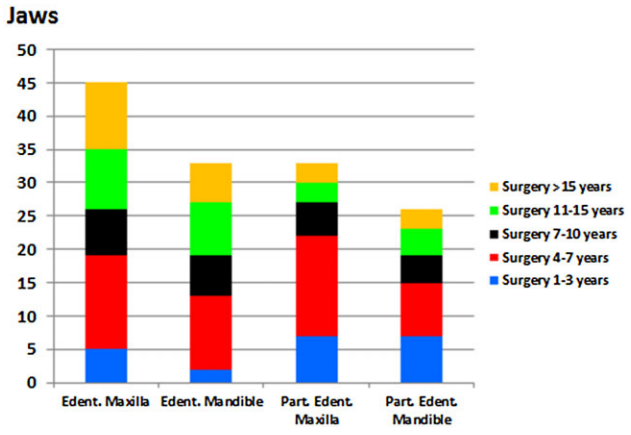

Figure 5 Distribution of included jaws with regard to type of jaws and time from first surgery to peri-implantitis surgery. Eight and one of the partially edentulous upper and lower jaws were provided with only one implant each, respectively (single implant).

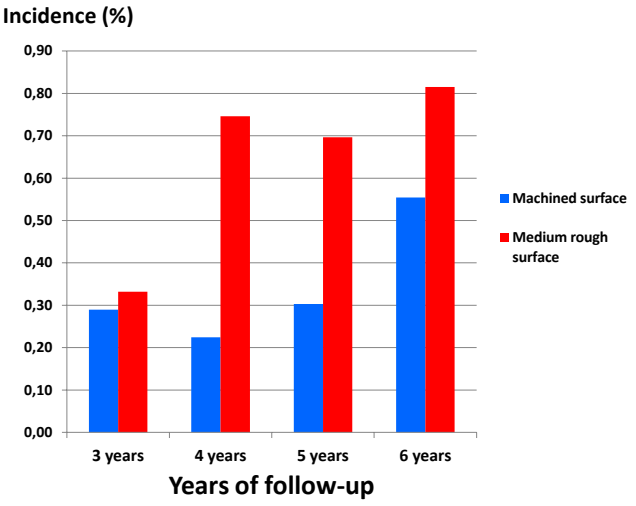

Figure 6 Mean incidence of peri-implantitis surgery for patients treated with a *machined* (Brånemark System) or *medium–rough* (TiUnite or Osseospeed or resorbable blast media [RBM] surface) implant surfaces. For comparison reasons are patients included from comparable 7-year periods of follow-up; *machined* – 1997 to 2003 and *medium–rough* – 2003 to 2009.

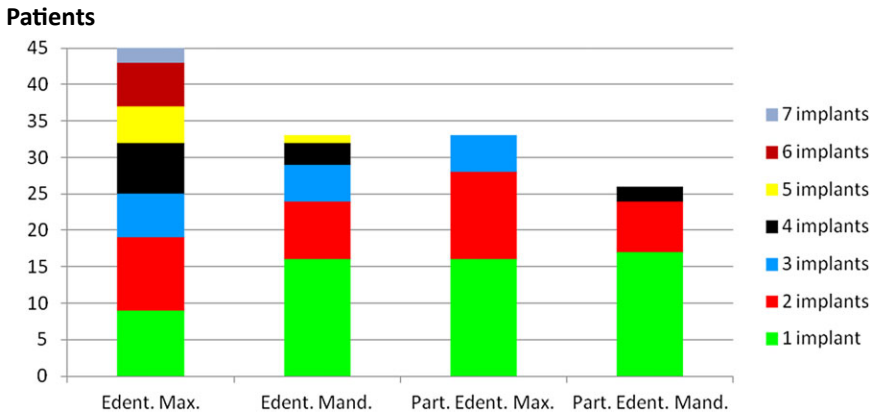

Figure 7 Distribution of jaws with regard to number of *affected* implants.

(Table 4). Twenty implants (3.2%) were removed in 17 patients (12.7%) *before* peri-implantitis surgery. Another 28 implants were removed in 24 patients *during* the peri-implantitis surgical intervention (10 loose and 18 integrated/surgically removed), resulting in a total of 48 removed implants (7.8%) in 37 individual patients (27.6%) in the study group.

Mean marginal bone levels for *affected* and *unaffected* implants were 3.4 mm (SD 1.44) and 1.4 mm (SD 0.65) at peri-implantitis surgery, respectively (Table 4).

TABLE 4 Patient Mean Marginal Bone Level in Relation to Implant/Abutment Junction (IAJ) for the Study Group and a Selected Reference Group*. Distributions of Bone Levels at Individual Implants Are Presented As Well. According to the Surgical Protocol,[24] Implants Were Placed with the Implant Neck Collar in Contact with Bone, Placed 0.8 mm Apical of IAJ

		Study Group			
		Affected	Unaffected	Total	Reference Group*
Mean time of follow-up (years)		9.2	9.2	9.2 SD 5.54	10
Number of patients (jaws)		134	107	134 (137)	315 (332)
Number of implants		283	294	577	1393
		Mean Bone Level in Relation to IAJ in mm			
Mean		3.4	1.4	2.4	1.6
SD		1.44	0.65	1.04	0.85
Implant thread	Bone Level to IAJ (mm)	Number of Individual Implants (%)			
IAJ	0.0–1.8	1 (0)	63 (21)	64 (11)	694 (50)
1st	1.9–2.4	7 (2)	147 (50)	154 (27)	409 (31)
2nd	2.5–3.0	32 (11)	63 (21)	95 (16)	155 (11)
3rd	3.1–3.6	53 (18)	13 (4)	66 (11)	86 (6)
4th	3.7–4.2	60 (20)	5 (2)	65 (11)	28 (2)
5th	4.3–4.8	33 (12)	2 (1)	35 (6)	6 (1)
6th	4.9–5.4	38 (13)	0	38 (7)	2 (0)
7th	5.5–6.0	22 (8)	1 (0)	23 (4)	2 (0)
8th	6.1–6.6	13 (5)	0	13 (2)	1 (0)
9th	6.7–7.2	4 (1)	0	4 (1)	0
10th	7.3–7.8	7 (2)	0	7 (1)	0
>10th	>7.8 mm	13 (5)	0	13 (2)	0

*Pooled data from consecutive patients in study reference 10, 12, 13, 31, 32, and 34.

Altogether, 264 of the examined implants (45.7%) presented bone levels at the third thread or below, more pronounced for *affected* implants. Corresponding patient mean bone levels for a reference group of selected studies[10,12,13,30,31,33] showed an average bone level of 1.6 mm (SD 0.85), and a total of 125 implants (9.0%) with bone levels at the third thread or below after 10 years in function (Table 4).

Unaffected implants were observed in a total of 107 jaws, indicating that 30 jaws presented only *affected* implants (Table 4). The most pronounced difference between mean bone levels for *affected* and *unaffected* implants was observed for edentulous lower jaws, where it also was most common that only one to two implants were *affected*, predominantly placed close to the midline in situations with five to six implants.

Altogether, 92 and 45 of the included jaws were provided with turned and medium–rough implants, respectively (Table 5). One of the jaws was provided with Lifecore Restore implants (medium–rough surface; 2.8%) and Astra Tech Implant System implants (medium rough surface; 1.0%), respectively. Considering total number of treated jaws during 25 years (Table 1), 1.5% and 1.4% of included jaws were provided with machined and medium–rough implant surfaces, respectively. The corresponding proportion of included implants was 1.6% and 1.7%, respectively.

Patient mean marginal bone levels for machined and medium–rough surfaces are presented in Table 5. Comparable mean bone levels can be observed for the different surfaces after an average of 11.5 (SD 5.15) and 4.4 (SD 1.66) years, respectively. Distributions of implants with bone levels at three threads or fewer were similar as well (66% and 65%, respectively).

DISCUSSION

Most patients were identified as peri-implantitis risk patients by the restorative dentists at the clinic. Because peri-implantitis problems were not specifically defined at the early period of inclusion, procedures of including these patients were much related to how periodontitis patients have been earlier handled in the clinic. By time, a more mature approach to these patients was established, more related to the nature and problems of the implants in the individual patients. Accordingly, it is important to notice that patients may not have been referred by the restorative dentists at the clinic, based on exactly the same criteria during the entire inclusion period. Furthermore, as the knowledge on peri-implantitis problems increased during the inclusion

TABLE 5 Patient Mean Marginal Bone Levels in Relation IAJ for Machined (Brånemark System) and Medium Rough (TiUnite, Osseospeed, RBM Surface) Implant Surfaces at the Time of Inclusion

		Marginal Bone Levels in Relation to IAJ					
		Machined			Medium–Rough*		
		Affected	Unaffected	Total	Affected	Unaffected	Total
Follow-up time			11.5 (SD 5.15)			4.4 (SD 1.66)	
Jaws			77	92		31	45
Implants		208	215	423	75†	79	154
Mean		3.4	1.3	2.4	3.3	1.5	2.4
SD		1.54	0.49	1.04	1.15	0.90	1.00
Thread	mm	Numbers of Implants (%)					
0 to 1st	0–1.1	6 (3)	153 (70)	159 (37)	2 (3)	57 (76)	59 (40)
2nd to 3rd	1.1–2.9	61 (29)	57 (28)	117 (28)	24 (33)	19 (20)	44 (27)
4th to 5th	2.9–4.1	68 (33)	5 (2)	73 (17)	25 (32)	2 (3)	27 (19)
6th to 7th	4.1–5.3	47 (23)	0	47 (11)	13 (17)	1 (1)	14 (9)
8th to 10th	5.3–6.5	14 (7)	0	14 (3)	10 (13)	0	10 (6)
>10th	>6.5	12 (6)	0	12 (3)	2 (3)	0	2 (1)

*Four LifeCore implants in one patient and three Astra Tech implants in one patient.
†One LifeCore and one Astra Tech implant each.
IAJ, implant/abutment junction.

period, it is reasonable to assume that the decision for surgery may vary during the inclusion period as well. Thus, the present results must be evaluated in relation to these observations that a routine protocol to identify and handle peri-implantitis patients has developed and have been increasingly more refined during the inclusion period. Still, even though this study covers a period of intense learning on peri-implantitis problems, the present data provide information on a topic that so far has been presented at a limited extent. Accordingly, the present results cover only the incidence on how many patients were surgically treated during the inclusion period of 8 consecutive years, not how many patients should have had surgical treatment according to the level of knowledge that is available today.

In the present study, *incidence* measures the risk for a patient to be surgically treated with problems related to peri-implantitis during a 1-year period of follow-up time. Based on a population of about 1,300 patients examined per year during an 8 years period of time, the present study reports an average incidence of peri-implantitis related surgery of 1.2% per year (Risk: 1/83 patients; Figure 4). Other studies report on numbers and different techniques of peri-implantitis surgery in different patient cohorts,[34–37] but no study has been found that has reported comparable data on incidence of surgery in larger groups of patients. Instead, most clinical peri-implantitis population studies have focused on calculation of *prevalence* of peri-implantitis in different cohorts.[17–21] In contrast to calculate the present risk, prevalence measures the total number of patients that have been affected by peri-implantitis at a certain time of observation in a group, according to a given definition. Accordingly, incidence measurements provide information on the *risk of new patients* with a certain problem/treatment, while prevalence more covers the *history* of a certain problem/treatment during a given period of follow-up. This means that longitudinal measurements of incidence may earlier provide information of changes in a complication pattern after, for example, new techniques have been introduced. Since measurements for *incidence* and *prevalence* are based on different calculations, results are not comparable. Furthermore, the present results cover only patients that have been treaded, while data on prevalence of peri-implantitis usually cover all patients that are included according to specific criteria. This can be exemplified by the obvious difference in the present incidence (1.2%) and previous prevalence figures,[20] reported from the same clinic (28%).

The mean time of follow-up after prosthesis placement was 9.1 years before peri-implantitis surgery was performed, with a maximum range from 1 to 23 years. The highest number of patients was observed from 4 to 7 years after prosthesis placement (Figure 5). However, considering the pattern of patients lost to follow-up (Figure 3), a high proportion of patients were also included who presented longer follow-up periods than 7 years in function (Figures 4 and 5). Accordingly, a total of 50% of the patients were included with a longer time of follow-up than 7.5 years. Considering also the patients presenting problems during the very first year they have been excluded in the present study (n-31; Table 2), surgery related to peri-implantitis problems could be observed very early as well as after a long time after prosthesis placement. Based on the observation that peri-implantitis problems may increase by time but also could be observed very early, it could be questioned if the etiology for surgery is the same for these early and late treated patients.

Different types of treated jaws seem to present different patterns of problems, where the edentulous upper jaw here showed a significantly higher percentage of surgery as compared with other groups of patients ($p < .05$). These patients showed a wide variation of edentulous upper jaws with regard to number of *affected* implants (Figure 7). On the other hand, treatment of the edentulous mandible resulted in problems predominantly focused to one or two implants (Figure 7), mostly placed in the anterior region close to the midline (73%). This observation has been observed by others,[30,38] today resulting into a modified first implant surgical protocol where implants are not placed close to the midline in the edentulous mandible anymore.[24]

During the last decades, much attention has been focused on different surfaces on the implants. Wennerberg[39] showed that a medium rough implant surface induced a more favorable early bone response than turned and more rough surfaces. The results indicated an earlier and more predictable integration of the implants, which allowed for safer osseointegration and early loading. Later clinical reports have confirmed these animal results,[40] and the medium rough implant surface is today the surface of choice in implant dentistry. However, later animal studies have indicated that the medium–rough implant surface may interact more

actively in the inflammatory process, when obvious mucosal inflammation is present.[41] So far, this observation has not been possible to find support for in the clinic, even though there are some weak, but statistically insignificant, indications of more bone loss at medium–rough surfaces as compared with turned surfaces during follow-up.[33,40,42–44] The present study comprises both implants with turned and medium–rough surfaces (Tables 1 and 5). Proportions of affected implants seem to be comparable in the present material, also including comparisons between different manufacturers (Table 5). However, considering the incidence of surgery for comparable years of follow-up, a consistent, but small statistically insignificant, difference of 0.05% to 0.5% in favor for the turned surface could again be observed for all years that could be compared (Figure 6).

It can be observed that included patients in the study group present obvious differences in bone levels (bone loss) during follow-up compared with previous retroprospective cohort studies at the clinic (Table 4).[10,12,13,31,32,34] This emphasizes the difference in patient inclusion, where in the earlier cohort groups, patients were consecutively included following implant treatment, while patients in the present study are only included if they have been surgically treated due to peri-implantitis. A different and more obvious bone response in patients associated to peri-implantitis has been reported in an earlier study from the clinic, also indicating higher patient mortality than for normal populations.[45] This higher mortality suggested obvious general health problems in this selected group of patients.[45] As the biological response to implants is of a foreign body character,[1,2] pronounced bone resorption at the implants may indicate that the biological balance may be disturbed in some of these patients, affecting both general health conditions as well as the marginal bone at the implants.

CONCLUSIONS

Within the limits of the present study, the following conclusions could be made:

- Incidence of surgery related to peri-implantitis ranged between 0.4% and 2.4% of examined follow-up patients per year between 2003 and 2010. Mean incidence was 1.2% with a risk evaluation of one patient out of 83 examined follow-up patients. As no data was available on patient compliance, it could be assumed that the result may underscore the clinical need.
- Calculated incidence of included surgically treated patients in relation total number of implant placement surgeries per year ranged between 0.0% and 3.5%. Mean incidence was 1.5% (SD 1.04) per year.
- Significantly, more edentulous upper jaws ($p < .05$) were included for peri-implantitis surgery than any other clinical situation.
- Significantly, more female patients ($p < .05$) were treated with surgery.
- There was a tendency of time dependence in the study group, indicating that the risk for peri-implantitis surgery increased by time.
- There was no significant difference in incidence between patients provided with implants with a machined or a medium–rough surface when considering comparable years of follow-up (3–6 years). However, a weak but consistent trend of a lower incidence of peri-implantitis surgery was observed for implants with a machined surface.

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