A Retrospective Analysis of Patients Referred for Implant Placement to a Specialty Clinic: Indications, Surgical Procedures, and Early Failures

Michael M. Bornstein, Dr Med Dent[1]/Sandro Halbritter, Dr Med Dent[2]/Hendrik Harnisch, Dr Med Dent[2]/Hans-Peter Weber, Prof Dr Med Dent[3]/Daniel Buser, Prof Dr Med Dent[4]

Purpose: *This retrospective study analyzed the pool of patients referred for treatment with dental implants over a 3-year period in a referral specialty clinic.* ***Materials and Methods:*** *All patients receiving dental implants between 2002 and 2004 in the Department of Oral Surgery and Stomatology, University of Bern, were included in this retrospective study. Patients were analyzed according to age, gender, indications for implant therapy, location of implants, and type and length of implants placed. A cumulative logistic regression analysis was performed to identify and analyze potential risk factors for complications or failures.* ***Results:*** *A total of 1,206 patients received 1,817 dental implants. The group comprised 573 men and 633 women with a mean age of 55.2 years. Almost 60% of patients were age 50 or older. The most frequent indication for implant therapy was single-tooth replacement in the maxilla (522 implants or 28.7%). A total of 726 implants (40%) were inserted in the esthetically demanding region of the anterior maxilla. For 939 implants (51.7%), additional bone-augmentation procedures were required. Of these, ridge augmentation with guided bone regeneration was performed more frequently than sinus grafting. Thirteen complications leading to early failures were recorded, resulting in an early failure rate of 0.7%. The regression analysis failed to identify statistically significant failure etiologies for the variables assessed.* ***Conclusions:*** *From this study it can be concluded that patients referred to a specialty clinic for implant placement were more likely to be partially edentulous and over 50 years old. Single-tooth replacement was the most frequent indication (> 50%). Similarly, additional bone augmentation was indicated in more than 50% of cases. Adhering to strict patient selection criteria and a standardized surgical protocol, an early failure rate of 0.7% was experienced in this study population.*
Int J Oral Maxillofac Implants 2008;23:1109–1116.

Key words: *dental implants, early failure, guided bone regeneration, indications, sinus grafting procedures*

[1]Assistant Professor, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland.
[2]Resident, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland.
[3]Professor and Chairman, Department of Restorative Dentistry and Biomaterials Sciences, Harvard School of Dental Medicine, Boston, Massachusetts; Visiting Professor, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland.
[4]Professor and Chairman, Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland.

Correspondence to: Prof Dr Daniel Buser, Department of Oral Surgery and Stomatology, Freiburgstrasse 7, CH-3010 Bern, Switzerland. Fax: +41-31-632 98 84. E-mail: daniel.buser@zmk.unibe.ch

The replacement of missing teeth with endosseous implants for the rehabilitation of completely or partially edentulous patients has become a standard of care in dentistry in the past 20 years. This significant progress in implant dentistry is based on the concept of osseointegration first described by the research groups of Brånemark et al[1,2] and Schroeder et al.[3,4] These fundamental experimental studies demonstrated that titanium implants regularly heal with direct bone-to-implant contact, a process termed *osseointegration* or *functional ankylosis*.

In the past 2 decades, many clinical studies have demonstrated that implant integration can be achieved and maintained in various areas of the

Table 1 Age Distribution of Patients Receiving Dental Implants During the Years 2002–2004

Age	No. of patients	%	Women	Men
≤ 20 y	49	4.1	25	24
21–30 y	104	8.6	54	50
31–40 y	134	11.1	72	62
41–50 y	221	18.3	107	114
51–60 y	339	28.1	179	160
61–70 y	266	22.1	149	117
71–80 y	81	6.7	40	41
> 80 y	12	1.0	7	5
Total	1,206	100	633	573

mouth on a long-term basis using different implant systems. Good long-term documentation is available for several commercially available implant systems, including the Brånemark System (Nobel Biocare, Göteborg, Sweden), the Straumann Dental Implant System (Straumann, Basel, Switzerland), the Osseotite Implant System (3i/Implant Innovations Inc, Palm Beach, FL, USA), and the Astra Tech Dental Implant System (Astra Tech, Mölndal, Sweden). For these systems, prospective long-term studies have exhibited survival and success rates clearly exceeding 90% at 5- and 10-year follow-ups.[5–16]

Based on these scientific findings, osseointegrated dental implants have become a routinely used therapy in private practice. Because of the predictability of osseointegrated implants, treatment planning in dental medicine has changed significantly in the past 15 years.[17] The tremendous expansion of implant therapy observed in private practice has mainly been caused by the following aspects[18,19]: (*1*) much better acceptance of implant therapy by patients and clinicians; (*2*) the broadened spectrum of indications for implant therapy in partially edentulous patients; (*3*) the simplification of implant therapy, especially in uncomplicated cases, for example, with shortened healing periods using implants with microrough surfaces; (*4*) the tremendous progress with bone augmentation procedures that enable implant placement in sites with local bone deficiencies.

The aim of the present study was to evaluate the pool of implant patients referred by their dental practitioners to the Department of Oral Surgery and Stomatology at the University of Bern for implant placement over a 3-year period (2002 to 2004). The patient cohort was analyzed according to indication for implant therapy, age, gender, and need for bone additional augmentation procedures. Furthermore, complications leading to early failure during the healing period, ie, prior to prosthetic reconstruction, were analyzed.

MATERIALS AND METHODS

Patient Selection

All patients receiving dental implants after being referred to the Department of Oral Surgery and Stomatology, School of Dental Medicine, University of Bern, Switzerland, during a 3-year period from 2002 to 2004 were included in this study. Candidates with severe systemic health problems (immunocompromised patients, patients with irradiated bone, etc) were excluded, but patients with local maxillary or mandibular bone defects requiring local horizontal bone augmentation or sinus floor elevation procedures, along with smokers, were included. In heavy smokers, staged augmentative procedures were not performed.

Clinical Procedures

Surgical procedures were carried out under local anesthesia (Ultracain DS forte, Aventis Pharma, Zurich, Switzerland) employing a low-trauma surgical technique. All patients received premedication with atropine (0.5 mg intramuscularly) and antibiotic prophylaxis beginning 2 hours prior to surgery (Aziclav, 1 g two times per day for 6 days; Spirig Pharma, Egerkingen, Switzerland). All implants were placed using a standardized surgical procedure by 14 different surgeons. Four were experienced senior surgeons (inserting 881 implants/48.5%) and 10 were postgraduate students in oral surgery (inserting 936 implants/51.5%). The postgraduate students always had the assistance of an experienced instructor during surgery for quality assurance purposes. Details of presurgical evaluation, surgical techniques, and postoperative treatment have been previously published.[20–22]

After a healing period of 6 to 8 weeks (for implants inserted without bone augmentation) or 10 to 14 weeks (after local bone augmentation or sinus floor elevation), prosthetic rehabilitation was initiated by the referring practitioners in their private offices.

Statistical Analysis

The following parameters were evaluated using descriptive methods (Excel for Office XP/2000, Microsoft, Redmond, WA, USA):

- Indication for implant placement. For all patients, the indication for insertion of an implant was characterized as edentulous jaws, distal-extension situations, extended edentulous gaps, and single-tooth gaps.
- Distribution of implants by location. The location was determined by the exact tooth replaced by an implant; the jaws were grouped into 4 quadrants (anterior = canine to canine, posterior = premolars

Table 2 Distribution of Implants Placed in the Years 2002–2004 (n = 1,817) According to Indication

	Patient			Implant		
Indication/region	No.	Subtotal (%)	Combined (%)	No.	Subtotal (%)	Combined (%)
Single-tooth gap						
Maxilla	469	38.9	56.2	522	28.7	41.3
Mandible	208	17.3		229	12.6	
Distal extension						
Maxilla	114	9.4	21.1	227	12.5	26.7
Mandible	141	11.7		258	14.2	
Extended edentulous gap						
Maxilla	131	10.9	17.2	274	15.1	22.6
Mandible	76	6.3		136	7.5	
Edentulous jaw						
Maxilla	16	1.3	5.5	55	3.0	9.4
Mandible	51	4.2		116	6.4	
Total	1,206	100.0	100.0	1,817	100.0	100.0

and molars, in each arch). Additionally, implants placed in the so-called esthetic region of the mouth (maxillary left first premolar to right first premolar) were analyzed.

- Distribution of implants by diameter and length.
- Type of augmentation procedure. Implants were classified as inserted with simultaneous guided bone regeneration (GBR), staged GBR, or sinus floor elevation (SFE) either by a simultaneous or staged lateral window technique or simultaneous osteotome technique.
- Analysis of complications and early failures. Implants inserted without additional augmentation techniques were followed up after 1, 2, and 6 to 8 weeks postoperatively before patients were referred back to their restorative clinicians. Implants placed with a GBR or sinus graft procedure were recalled after 1, 2, 4, 8, and 10 to 14 weeks following surgery. Implants that failed to integrate and subsequently had to be removed during the initial healing period were classified as early failures.

To identify potential factors for increased failure risk, a multiple cumulative regression analysis was performed using the SAS 9.1 program (SAS Institute, Cary, NC). The dependent variable was the performance of the implant in the initial healing period (success/failure). Influencing variables were age, gender, smoking status (none/light/heavy), indication for implant placement, implant location, implant diameter and length, and type of augmentation procedure used in combination with the inserted implant (no augmentation/any type of augmentation). The significance level chosen for all statistical tests was $P < .05$.

RESULTS

Descriptive Analysis of the Patient Pool

Over the assessed 3-year period, 1,206 patients received a total of 1,817 dental implants with a sandblasted and acid-etched surface (SLA) (Straumann Dental Implant System, Straumann) at the Department of Oral Surgery and Stomatology. The group comprised 573 men and 633 women with a mean age of 55.2 years (range, 18 to 92 years). Fifty-eight percent of patients were over the age of 50 (Table 1). There were 965 nonsmokers, 169 light smokers (1 to 10 cigarettes per day), and 72 heavy smokers (11 or more cigarettes per day).

Indication for Implant Placement. The most frequent indication for implant placement was single-tooth gaps in the maxilla (522 implants/28.7%). This was followed by extended edentulous gaps in the maxilla (274 implants/15.1%) and distal-extension situations in the mandible (258 implants/14.2%). A detailed analysis is presented in Table 2.

Distribution of Implants by Location. The most frequent location for implant placement was the first molar region in the mandible (320 implants/17.6%), followed by the central incisor area in the maxilla (240 implants/13.2%) and the first premolar location in the maxilla (227 implants/12.5%) (Table 3). Implants were indicated more often in the maxilla than in the mandible (1,077 implants versus 740 implants), and implant placement in posterior regions of the jaws was more frequent than in anterior regions (1,158 implants versus 659 implants) (Table 4). A total of 726 implants (40% of all implants) were placed in the esthetically demanding anterior region of the maxilla (maxillary left premolar to right first premolar).

Table 3 Distribution of the Implants (n = 1,817) According to Location*

Maxilla	17 (2)	16 (3)	15 (4)	14 (5)	13 (6)	12 (7)	11 (8)	21 (9)	22 (10)	23 (11)	24 (12)	25 (13)	26 (14)	27 (15)	Total
No. placed	5	75	97	116	49	79	115	125	81	50	111	85	87	2	1,077
Mandible	**47 (31)**	**46 (30)**	**45 (29)**	**44 (28)**	**43 (27)**	**42 (26)**	**41 (25)**	**31 (24)**	**32 (23)**	**33 (22)**	**34 (21)**	**35 (20)**	**36 (19)**	**37 (18)**	**Total**
No. placed	17	151	63	52	61	11	9	8	10	59	43	68	169	19	740

*FDI notation used, with Universal numbers in parentheses.

Table 4 Distribution of the Dental Implants in Different Regions of Each Jaw

Region	Implants	%
Anterior maxilla	500	27.5
Posterior maxilla	577	31.7
Anterior mandible	159	8.8
Posterior mandible	581	32.0
Maxillary implants	1,077	59.3
Mandibular implants	740	40.7
Anterior implants	659	36.3
Posterior implants	1,158	63.7

Anterior maxilla/mandible = canine to canine.
Posterior maxilla/mandible = premolars/molars in each arch.

Table 5 Distribution of the Inserted Implants (n = 1,817) by Type and Length

	No. placed	%
Implant type		
Standard 4.1-mm	1,003	55.2
Standard 4.8-mm	251	13.8
Wide neck 4.8-mm	279	15.3
Narrow neck 3.3-mm	151	8.3
Standard 3.3-mm	19	1.1
TE	112	6.2
Prototype implants	2	0.1
Implant length		
14 mm	40	2.2
12 mm	790	43.5
10 mm	808	44.4
8 mm	154	8.5
6 mm	25	1.4

TE = tapered effect implant design.

Table 6 Type of Augmentation Procedure Used in Combination with the Inserted Dental Implants (n = 1,817)

Surgical procedure	Implants	%
Implants with GBR		
Simultaneous GBR	599	33.0
Staged GBR	123	6.7
GBR total	722	39.7
Implants with SFE		
Simultaneous osteotome technique	35	1.9
Simultaneous window technique	106	5.8
Staged window technique	60	3.3
Sinus graft total	201	11.0
Implants with simultaneous SFE and GBR	16	0.9
Total implants with augmentation procedures (GBR and/or SFE)	939	51.7
Implants without augmentation procedures	878	48.3

Distribution of Implants by Diameter and Length. The standard implant diameter of 4.1 mm (1,003 implants/55.2%) and implant lengths of 10 mm (808 implants/44.4%) and 12 mm (790 implants/43.5%) were most frequently used (Table 5).

Type of Augmentation. A total of 939 implant sites (51.7%) needed some type of bone augmentation procedure. Implants requiring bone augmentation with the GBR technique were more frequent than those needing sinus floor elevation procedures (722 implants versus 201 implants) (Table 6). A separate analysis of implants placed in the anterior esthetically demanding region of the maxilla showed that a total of 542 implants needed a simultaneous (447 implants) or staged (95 implants) GBR procedure. This means that almost three fourths (74.7%) of the 726 implants inserted in this area required additional local bone augmentation.

Clinical Observations and Complications

Following surgery, patients reported no or only moderate discomfort in the areas of surgery. In 37 patients (3.1% of the 1,206 patients treated), postoperative bleeding was observed, which could be con-

Table 7 Early Failures Among the Inserted Dental Implants*

Implant	Age (y)	Gender	Smoking status	Implant site†	Indication	Implant length (mm)	Implant type	Augmentation procedure
1	50	M	Heavy	15 (4)	Single-tooth gap	10	S 4.1	No
2	88	F	No	11 (8)	Distal extension	10	S 4.1	No
3				13 (6)	Distal extension	12	S 4.1	No
4	46	F	No	35 (20)	Single-tooth gap	10	WN 4.8	No
5	62	M	No	15 (4)	Distal extension	10	WB 4.8	Staged SFE
6	69	F	No	43 (27)	Distal extension	12	S 4.1	No
7				36 (19)	Single-tooth gap	10	WN 4.8	No
8	62	M	No	25 (13)	Distal extension	10	S 4.8	Simultaneous SFE
9	67	F	No	44 (28)	Single-tooth gap	12	NN 3.3	Simultaneous GBR
10				16 (3)	Single-tooth gap	12	WN 4.8	Simultaneous SFE
11	69	M	Heavy	33 (22)	Edentulous	12	S 4.1	No
12	71	M	No	34 (21)	Single-tooth gap	10	TE	No
13	19	F	Light	34 (21)	Extended edentulous gap	10	S 4.1	Staged GBR

*Early failure = during initial healing; 13 implants in 10 patients.
†FDI notation used, with Universal Numbering System in parentheses.
S = standard; WN = wide neck; NN = narrow neck; TE = tapered effect implant design; GBR = guided bone regeneration; SFE = sinus floor elevation.

trolled with local hemostatic measures. Temporary hypesthesia of the regional nerve was found in 15 patients (1.2% of the 1,206 patients treated), but no permanent hypesthesia or anesthesia was observed. In 12 patients the inferior alveolar nerve was affected and in 3 patients the infraorbital nerve was affected.

Twenty-eight implants (1.5% of the 1,817 implants inserted) showed signs of peri-implant inflammation during the initial healing period. The inflammatory process was contained and resolved with daily local disinfection using 3% hydrogen peroxide and 0.2% chlorhexidine gel for up to 1 week (Plak-Out Gel, Hawe Neos Dental, Bioggio, Switzerland). In 3 of the 28 sites, the implants subsequently developed instability and revealed a peri-implant infection with suppuration, and were therefore removed. Implant failure during the healing period without any signs of inflammation or infection but with progressive mobility of the inserted implant was found in 10 patients. The resulting total early failure rate was 0.7% (13 of 1,817 inserted implants). The failures occurred in 10 different patients (6 men and 4 women). Details on the 13 failed implants are presented in Table 7.

The remaining 1,804 implants showed healthy peri-implant tissues and remained stable throughout the healing period. The final clinical examination in the Department of Oral Surgery and Stomatology, which occurred after 6 to 8 weeks for implants without augmentation procedures and after 10 to 14 weeks for implants requiring local bone augmentation, demonstrated healthy clinical and radiographic conditions. Subsequently, the patients were sent back to their restorative clinicians for the prosthodontic phase of treatment.

Regression Analysis

The multiple cumulative regression analysis to detect contributing factors for early implant failure revealed no statistically significant influence of age, gender, indication for implant placement, implant location (maxilla/mandible), implant diameter and length, or type of augmentation procedure used in combination with the inserted implant (no augmentation versus any type of augmentation). Patient smoking status did not appear to be a significant risk overall, although heavy smoking (> 10 cigarettes per day) came closest to being a statistically significant risk factor.

DISCUSSION

The predictability of dental implants has introduced a significant change in treatment planning and treatment of fully and partially edentulous patients over the past 10 to 20 years. Implants with enhanced surfaces as currently in use reveal success rates of around 99% after 5 years of function, despite shorter healing times of only 6 to 8 weeks.[23–27] Furthermore, the range of indications for dental implants has broadened tremendously, which is another important factor for the increasing popularity of implant dentistry among clinicians and patients. It has been reported that over the past 2 decades the patient profile has shifted more and more from the edentulous to the partially edentulous, including missing single teeth. In a survey of Swiss dental practitioners in the year 1994,[28] the most frequent indication for implant placement was the edentulous mandible,

followed by distal-extension situations in the mandible. Single-tooth gaps in the anterior maxilla only ranked third. In contrast, a study from the University of Geneva reported that 80% of 1,352 inserted implants were placed in partially edentulous patients, leaving only one fifth of the implants for indications in edentulous jaws.[29] This trend was even more pronounced in an earlier retrospective study.[30] Partially edentulous patients accounted for more than 90% of all implant patients treated, and a single-tooth gap was the most frequent indication for implant placement (51.6% of patients and 35.5% of implants, respectively).

The trend toward fewer completely edentulous patients and more partially edentulous patients among those referred for implant therapy was further confirmed in the present study. Only 5.5% of all patients treated (accounting for 9.4% of all implants placed) were edentulous. In contrast, more than half of the patients were referred for the treatment of a single-tooth gap. In addition to the first molar region in the mandible and the first premolar area in the maxilla, which accounted for 30.1% of all implants, the maxillary central incisor region was the most frequent indication for implant insertion (13.2%, or 140 implants). In the interforaminal region, only 158 implants were indicated and placed during the study period (8.7% of all implants).

The introduction of alveolar ridge augmentation procedures such as GBR and SFE has also greatly contributed to the stated increase in the range of indications for implant therapy in daily practice. Until the late 1980s, potential implant patients with vertical and/or horizontal bone deficiencies or widely pneumatized maxillary sinuses could not undergo surgical treatment. With GBR and SFE, both of which are scientifically well established and have been documented in numerous clinical studies,[31–35] the clinician has surgical options to overcome these anatomic obstacles. In the present study, more than half of the implants were inserted using a simultaneous or staged GBR technqiue and/or SFE procedure. It is also interesting that in the esthetic zone (between and including the maxillary first premolars), almost three quarters of the implants inserted needed a GBR procedure. In most cases this was done simultaneous with implant placement (447 implants); only 95 implants had ridge augmentation completed in a staged procedure. Because of the retrospective nature of the study, it was not possible to clearly identify in which cases simultanuous GBR procedures were performed to regenerate missing bone to enable implant placement or for esthetic site enhancement only. This point would be interesting to evaluate in future prospective studies. Additionally, implant design aspects could also influence the need for GBR procedures. Comparative studies with different implant neck designs, which could clarify the impact of this variable on the frequency of augmentation procedures, are currently not available.

The observed postsurgical outcomes in the present study compare well with the existing information in the literature. A recent systematic review of the incidence of biologic and technical complications in implant dentistry reported in prospective longitudinal studies with observation periods of at least 5 years showed that the rate of implant loss prior to functional loading was about 2.5%.[36] Implant loss during function occurred in about 2% to 3% of implants supporting fixed reconstructions. For implants with the SLA surface, as were used in the present study, the results look even better. Cochran and coworkers[24] evaluated, in a multicenter study, titanium implants with the SLA surface in various clinical situations with up to 2 years of follow-up. Of 383 implants placed, 3 failed during the initial healing period, resulting in an early failure rate of 0.8%. Similar data were reported in a recent prospective 5-year follow-up study.[27] Of 104 implants initially inserted in posterior sites in 51 partially edentulous patients, 1 failed to integrate during healing, resulting in an early failure rate of 1%. By comparison, 13 implants were lost during the healing period in the present study, resulting in an early failure rate of 0.7%.

One important factor in achieving predictable short-term and long-term results in implant dentistry is the use of clear and concise patient selection criteria. Patients treated with dental implants in the Department of Oral Surgery and Stomatology are assessed using well-established patient risk assessment criteria.[21] The importance of strict patient selection criteria was also emphasized in a recent study in which SLA implants were loaded at 6 weeks after placement and followed for 12 months.[37] All patients treated with dental implants in that study, which had a 1-year success rate of 100%, were healthy and nonsmokers.

Increased failure rates have to be expected in patients exhibiting risk factors such as systemic diseases, heavy smoking, increased periodontal susceptibility, and anatomic factors such as poor bone density or extreme atrophy.[38] Elevated rates of implant failure have been associated with heavy smoking,[39,40] and smoking cessation programs have been recommended prior to implant placement.[41,42] In a recent systematic review, 1,057 implants placed in 218 patients were followed over a period of 9 to 14 years.[43] In that study, implant failure was defined as peri-implantitis with alveolar bone loss affecting more than 3 threads of the implant. Smokers had a higher risk of developing peri-implantitis, leading to

subsequent failure and eventual loss of the implant. Although statistically not significant in the present study, heavy smoking was the factor that came closest to statistical significance in the regression analysis performed to detect important factors influencing early failure of dental implants.

Immediate implant placement in extraction sites was not performed in the present study. There is no scientific evidence available in the current literature to support the conclusion that this approach effectively reduces the need for GBR procedures without increasing the long-term risk of esthetic complications. In contrast, in a recent multicenter randomized controlled clinical trial analyzing the surgical outcomes of 208 immediate implants (anterior maxilla and mandible, including premolars), the authors reported that additional bone grafting was indicated in more than 90% of cases.[44] Histometric results from a recent experimental study in canine mandibles, in which implants with a SLA surface were placed into fresh extraction sockets,[45] revealed a mean loss of crestal bone height of ≥ 2 mm on the buccal aspects of the implants after 12 weeks of healing. Critics will point out that, in the cited animal study, full-thickness flaps were elevated, depriving the exposed bone of vascularization and leading, consequently, to bone loss. Some authors have therefore claimed that flapless surgery may be an answer to this problem. Flapless procedures are reported to be minimally invasive, which may be beneficial for patients to reduce preoperative anxiety and postoperative discomfort and may, therefore, increase the treatment acceptance rate.[46,47] Flapless implant surgery has also been suggested as a means to enhance implant esthetics.[48] It is the authors' interpretation that there is currently no scientific evidence available to support the suggestion that flapless implant surgery should be the treatment of choice. On the contrary, it should be considered with caution and be limited only to carefully selected patients for whom evidence of sufficient horizontal and vertical hard and soft tissue has been obtained with appropriate diagnostic procedures.[49]

CONCLUSIONS

Based on the results of this retrospective analysis of a large patient sample, it can be concluded that patients referred by their clinicians to a specialty clinic for implant placement are more likely partially edentulous and over 50 years old. The likelihood that a single tooth space represents the indication for implant treatment is greater than 50%. Similarly, additional bone-augmentation procedures are indicated in more than 50% of cases. Adhering to strict patient selection criteria and a standardized surgical protocol, an early failure rate of only 0.7% was experienced.

ACKNOWLEDGMENTS

The authors would like to thank Mrs Claudia Moser, Mrs Olivia Schrag, and Mrs Renate Balz, Department of Oral Surgery and Stomatology, University of Bern, for their logistic support during this study.

REFERENCES

1. Brånemark P-I, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81–100.
2. Brånemark P-I, Hansson BO, Adell R, et al. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg 1977;16(suppl):1–132.
3. Schroeder A, Pohler O, Sutter F. Gewebsreaktion auf ein Titan-Hohlzylinderimplantat mit Titan-Spritzschichtoberfläche. Schweiz Monatsschr Zahnheilk 1976;86:713–727.
4. Schroeder A, van der Zypen E, Stich H, Sutter F. The reaction of bone, connective tissue and epithelium to endosteal implants with titanium-sprayed surfaces. J Maxillofac Surg 1981;9:15–25.
5. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. Long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
6. Zarb GA, Schmitt A. The longitudinal clinical effectiveness of osseointegrated dental implants: The Toronto study. Part I: Surgical results. J Prosthet Dent 1990;63:451–457.
7. Mericske-Stern R, Steinlin-Schaffner T, Marti P, Geering AH. Peri-implant mucosal aspects of ITI implants supporting overdentures. A five-year longitudinal study. Clin Oral Implants Res 1994;5:9–18.
8. Lekholm U, van Steenberghe D, Herrmann I, et al. Osseointegrated implants in the treatment of partially edentulous jaws. A prospective 5-year multi-center study. Int J Oral Maxillofac Implants 1994;9:627–635.
9. Buser D, Mericske-Stern R, Bernard JP, et al. Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. Clin Oral Implants Res 1997;8:161–172.
10. Behneke A, Behneke N, d'Hoedt B. The longitudinal effectiveness of ITI solid-screw implants in partially edentulous patients: A 5-year follow-up report. Int J Oral Maxillofac Implants 2000;15:633–645.
11. Weber HP, Crohin CC, Fiorellini JP. A 5-year clinical and radiographic study of non-submerged dental implants. Clin Oral Implants Res 2000;11:144–153.
12. Davarpanah M, Martinez H, Etienne D, et al. A prospective multicenter evaluation of 1,583 3i implants: 1- to 5-year data. Int J Oral Maxillofac Implants 2002;17:820–828.
13. Garlini G, Bianchi C, Chierichetti V, Sigurta D, Maiorana C, Santoro F. Retrospective clinical study of Osseotite implants: Zero- to 5-year results. Int J Oral Maxillofac Implants 2003;18:589–593.

14. Gotfredsen K. A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: A pilot study. Clin Implant Dent Relat Res 2004;6:1–8.
15. åstrand P, Engquist B, Dahlgren S, Gröndahl K, Engquist E, Feldmann H. Astra Tech and Brånemark system implants: A 5-year prospective study of marginal bone reactions. Clin Oral Implants Res 2004;15:413–420.
16. Sullivan D, Vincenzi G, Feldman S. Early loading of Osseotite implants after placement in the maxilla and mandible: A 5-year report. Int J Oral Maxillofac Implants 2005;20:905–912.
17. Lemmerman KJ, Lemmerman NE. Osseointegrated dental implants in private practice: A long-term case series study. J Periodontol 2005;76:310–319.
18. Buser D, Belser UC. Fortschritte und aktuelle Trends in der oralen Implantologie. Schweiz Monatsschr Zahnmed 1998;108:326–350.
19. Belser UC, Buser D, Hess D, Schmid B, Bernard JP, Lang NP. Aesthetic implant restorations in partially edentulous patients: A critical appraisal. Periodontol 2000 1998;17:132–150.
20. Buser D, Weber HP, Lang NP. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. Clin Oral Implants Res 1990;1:33–40.
21. Buser D, von Arx T, ten Bruggenkate CM, Weingart D. Basic surgical principles with ITI implants. Clin Oral Implants Res 2000; 11(suppl):59–68.
22. Weingart D, ten Bruggenkate CM. Treatment of fully edentulous patients with ITI implants. Clin Oral Implants Res 2000; 11(suppl):69–82.
23. Roccuzzo M, Bunino M, Prioglio F, Bianchi SD. Early loading of sandblasted and acid-etched (SLA) implants: A prospective split-mouth comparative study. Clin Oral Implants Res 2001; 12:572–578.
24. Cochran DL, Buser D, ten Bruggenkate CM, et al. The use of reduced healing times on ITI implants with a sandblasted and acid-etched (SLA) surface: Early results from clinical trials on ITI SLA implants. Clin Oral Implants Res 2002;13:144–153.
25. Roccuzzo M, Wilson TG. A prospective study evaluating a protocol for 6 weeks' loading of SLA implants in the posterior maxilla. One-year results. Clin Oral Implants Res 2002;13: 502–507.
26. Bornstein MM, Lussi A, Schmid B, Belser UC, Buser D. Early loading of titanium implants with a sandblasted and acid-etched (SLA) surface: 3-year results of a prospective study in partially edentulous patients. Int J Oral Maxillofac Implants 2003;18:659–666.
27. Bornstein MM, Schmid B, Belser UC, Lussi A, Buser D. Early loading of titanium implants with a sandblasted and acid-etched surface: 5-year results of a prospective study study in partially edentulous patients. Clin Oral Implants Res 2005; 16:631–638.
28. Lambrecht JT, Besimo CE, Guindy JS. Standortbestimmung der zahnärztlichen Implantologie in der Schweiz. Schweiz Monatsschr Zahnmed 1999;109:18–30.
29. Bernard JP, Belser UC, Marchand D, Gebran G. Implants et edentments partiels: Aspects chirurgicaux et prothetiques. Cahiers Proth 1996;96:85–95.
30. Sulzer TH, Bornstein MM, Buser D. Aktuelles Indikationsspektrum in der oralen Implantologie an einer Überweisungsklinik. Eine retrospektive 3-Jahres-Analyse bei 737 Patienten mit 1176 Implantaten. Schweiz Monatsschr Zahnmed 2004;114:444–450.
31. Buser D, Dula K, Hirt HP, Schenk RK. Lateral ridge augmentation using autografts and barrier membranes: A clinical study with 40 partially edentulous patients. J Oral Maxillofac Surg 1996;54:420–433.
32. Wallace SS, Froum SJ. Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review. Ann Periodontol 2003;8:328–343.
33. Del Fabbro M, Testori T, Francetti L, Weinstein R. Systematic review of survival rates for implants placed in the grafted maxillary sinus. Int J Periodontics Restorative Dent 2004; 24:565–577.
34. von Arx T, Buser D. Horizontal ridge augmentation using autogenous block grafts and the guided bone regeneration technique with collagen membranes: A clinical study with 42 patients. Clin Oral Implants Res 2006;17:359–366.
35. Esposito M, Grusovin MG, Coulthard P, Worthington HV. The efficacy of various bone augmentation procedures for dental implants: A Cochrane systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants 2006;21: 696–710.
36. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol 2002;29(suppl 3):197–212.
37. Neto PT, Camargo LOA. Prospective clinical evaluation of dental implants with sand-blasted, large-grit, acid-etched surfaces loaded 6 weeks after surgery. Quintessence Int 2004;35: 717–722.
38. van Steenberghe D, Jacobs R, Desnyder M, Maffei G, Quirynen M. The relative impact of local and endogenous patient-related factors on implant failure up to the abutment stage. Clin Oral Implants Res 2002;13:617–622.
39. Bain CA, Moy PK. The association between the failure of dental implants and cigarette smoking. Int J Oral Maxillofac Implants 1993;8:609–615.
40. Wilson TG Jr, Nunn M. The relationship between the interleukin-1 periodontal genotype and implant loss. Initial data. J Periodontol 1999;70:724–729.
41. Bain CA. Smoking and implant failure: Benefits of a smoking cessation protocol. Int J Oral Maxillofac Implants 1996;11: 756–759.
42. Ramseier CA, Mattheos N, Needleman I, Watt R, Wickholm S. Consensus report: First European Workshop on Tobacco Use Prevention and Cessation for Oral Health Professionals. Oral Health Prev Dent 2006;4:7–18.
43. Roos-Jansaker AM, Renvert H, Lindahl C, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part III: Factors associated with peri-implant lesions. J Clin Periodontol 2006; 33:296–301.
44. Lang NP, Tonetti MS, Suvan JE, et al. Immediate implant placement with transmucosal healing in areas of aesthetic priority. A multicentre randomized-controlled clinical trial I. Surgical outcomes. Clin Oral Implants Res 2007;18:188–196.
45. Araujo MG, Sukekava F, Wennström JL, Lindhe J. Tissue modeling following implant placement in fresh extraction sockets. Clin Oral Implants Res 2007;17:615–624.
46. Fortin T, Bosson JL, Isidori M, Blanchet E. Effect of flapless surgery on pain experienced in implant placement using an image-guided system. Int J Oral Maxillofac Implants 2006; 21:298–304.
47. Becker W, Goldstein M, Becker BE, Sennerby L. Minimally invasive flapless implant surgery: A prospective multicenter study. Clin Implant Dent Relat Res 2005;7(suppl 1):S21–27.
48. Oh TJ, Shotwell JL, Billy EJ, Wang HL. Effect of flapless implant surgery on soft tissue profile: A randomized controlled clinical trial. J Periodontol 2006;77:874–882.
49. Campelo LD, Camara JR. Flapless implant surgery: A 10-year clinical retrospective analysis. Int J Oral Maxillofac Implants 2002;17:271–276.