Clinical Experience of TiUnite™ Implants: A 5-year Cross-Sectional, Retrospective Follow-Up Study

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ABSTRACT

Background: Little is known of the long-term clinical and radiographic performance of moderately rough surface implants.

Purpose: The aim of the present retrospective investigation was to study two pioneer cohorts of patients, that is, the first patients to receive Brånemark System® implants with a moderately rough surface (TiUnite™, Nobel Biocare AB, Göteborg, Sweden) at the present clinic. TiUnite implants were inserted either in compromised bone sites in a mixed-mouth concept together with turned implants or used solely. Patients were followed up over a period of 5 years with regard to implant survival and the marginal bone response.

Materials and Methods: Patients who received both implant types (mixed group) comprised 41 subjects, and the second group (TiUnite group) comprised 70 subjects. A total of 110 turned and 68 TiUnite implants were placed in the mixed group, and 212 TiUnite implants in the TiUnite group. Follow-up radiographs were obtained at prosthesis placement and at the 1- and 5-year check-ups, and examined by independent observers.

Results: One turned (0.9%) and two TiUnite (2.9%) implants failed in the mixed group, and three implants (1.6%) failed in the TiUnite group, indicating no significant differences between surfaces or groups ($p < .05$). The mean marginal bone loss at 5 years was 0.6 mm to 0.8 mm, also indicating no significant differences for the two implant types tested in the mixed group.

Conclusions: Cumulative survival rates for the two implant surfaces were favorable at 5 years, and the marginal bone loss was low and similar for both implant surfaces.

KEY WORDS: 5-year study, moderately rough surface, oral implants, TiUnite

INTRODUCTION

Follow-up reports on the short-term clinical performance of implants with an oxidized, moderately rough TiUnite™ surface (Nobel Biocare AB, Göteborg, Sweden) in various jaw situations show most favorable results. Hence, early- or directly-loaded implants in partially and totally edentate maxillae and mandibles demonstrate survival rates of 96% to 100% at 6 months to 18 months of follow-up.[1–5] Also, in compromised situations, that is, in connection to implant insertion in the jawbone of limited volume and soft texture, or in connection to implant insertion in fresh extraction sites as well as in connection to implant insertion together with augmentation procedures, these implants have indicated survival figures reaching 95% to 100% at 12 months to 36 months of follow-up.[6–10] However, few reports describe the results after longer functional periods with TiUnite implants, albeit 3-year, 4-year, and 5-year data on immediate loading are available[11–13] and showing survival rates of 97% and 100%.

A series of studies present mean values of marginal bone resorption around TiUnite implants within 0.4 mm to 1.4 mm during the first year of function,[1–13]

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which are in accordance with previous studies on turned implants.[14,15] Of more interest, though, is the marginal bone response over longer time periods around this moderately rough implant surface. In an experimental dog model, it has been raised that TiUnite implants may show more bone loss as compared with other commercially available implants when being exposed to plaque accumulation after initial ligature exposure.[16] Clinical studies comparing the short-term use of Brånemark System® implants with turned and TiUnite surfaces in various jaw situations have failed to demonstrate such a relationship, but instead have shown similar bone response and tendencies toward higher survival rates for the TiUnite implants.[8,12,17–20]

The purpose of the present investigation was retrospectively to follow up two cohorts of patients of which one received both turned and TiUnite implants and one received TiUnite implants only. Patients were followed up for 5 years with clinical and radiographic check-ups. Frequency distributions of implants with various marginal bone resorption were calculated.

MATERIALS AND METHODS

Altogether, 3,266 patients were referred to the Brånemark Clinic (Göteborg, Sweden) for prosthetic consultation or treatment from October 2000 to September 2003. Out of these patients, 1,051 patients received altogether 3,026 osseointegrated implants at the clinic. The inclusion period corresponds to when the clinic first started and gradually changed from the use of only turned implant surfaces to the TiUnite ones. The present 5-year follow-up study covers 113 of these first patients (10.8%), who were provided with at least one Brånemark System implant (Nobel Biocare AB) with a TiUnite surface. The remaining 938 patients were provided with implants with only turned surfaces. Patients included were either part of an early prospective study on TiUnite surfaces[4] or chosen by the surgeon when more difficult sites were identified when placing implants with turned surfaces. Gradually, there was an increase of patients that were provided with TiUnite implants only. Excluded from the present group were one patient deceased before prosthesis placement and one patient prosthetically treated by the referral dentist. The remaining 111 patients were arranged into two different groups and followed up from implant placement to the 5-year examination. Accordingly, the two groups comprised of patients that either received standard Brånemark System implants (Nobel Biocare AB) with turned surfaces, but where one or several Brånemark System implants with TiUnite surfaces were placed during the same surgical procedure (mixed group), or patients who received only Brånemark System implants with TiUnite surfaces (TiUnite group) during the inclusion period. The two groups that cannot be completely comparable comprised of 41 and 70 subjects, respectively.

Females predominated in the mixed group ($n = 29$), and the mean age was 59.4 years (SD 13.60) at implant placement. Age ranged from 17 years to 87 years at the first surgery. Males predominated in the TiUnite group ($n = 39$), and the mean age was 49.4 years (SD 22.55) and ranged from 17 years to 89 years in this group. The medical history revealed more than 50% healthy subjects in both groups, and 62% and 70% of the patients denied smoking habits in the mixed and TiUnite groups, respectively.

Maxillae predominated in the mixed group, while in the TiUnite group proportionally more mandibles were treated (Table 1). In the latter group, there was also a large representation of single-tooth procedures (see Table 1). Available jawbone quantity and quality was

TABLE 1 Numbers of Prostheses in the Upper and Lower Jaws

	Number of Prostheses					
	Upper Jaws			Lower Jaws		
Groups	Edentulous	Partially Edentulous	Single	Edentulous	Partially Edentulous	Single
Mixed*	18	17	5	1	4	0
TiUnite†	5	10	25	19	7	6
Total	23	27	30	20	11	6

*Two patients provided with one single and one partial prosthesis in the maxilla, and one patient provided with three single crowns in the maxilla.
†Two patients provided with two prostheses each bilaterally in the mandible.

TABLE 2 Distributions of Implants (%) in the Mixed Group with Regard to Bone Resorption and Bone Quality at the Implant Site (Index by Lekholm and Zarb[21])

	Bone Resorption				
Bone Quality	A	B (63/36)	C (29/22)	D (14/8)	E (4/2)
1 (0/0)					
2 (13/7)		4.5/**1.5**	4.5/**2.9**	–/**4.4**	2.7/**1.5**
3 (80/33)		42.7/**26.5**	16.4/**16.2**	12.7/**4.4**	0.9/**1.5**
4 (17/28)		10.0/**25.0**	5.5/**13.2**	–/**2.9**	–/–

Number of implants within parentheses (turned/TiUnite).

judged from preoperative radiographs and from perception during drilling, and classified according to the proposed criteria by Lekholm and Zarb.[21] The distributions of implants with regard to jawbone quality and quantity at the implant sites for the mixed group are shown in Table 2. For the TiUnite group, 43.4%, 41.0%, and 15.6% of the implants were placed in bone quality 2, 3, and 4, respectively.

Implant placement followed the guidelines described by Widmark and colleagues.[22] Surgery was predominantly performed in two steps, but 18 patients had implants placed according to a one-stage protocol in the TiUnite group, mostly performed in the edentulous mandible.[19]

Patients of the mixed group received altogether 110 turned and 68 TiUnite Brånemark System® Mk III and Mk IV implants (Nobel Biocare AB), while in the TiUnite group, 212 TiUnite Mk III and Mk IV implants were inserted (Tables 3 and 4). The distribution of implants with regard to length is shown in Table 5.

All patients provided with implant-supported prostheses were followed up according to the same strict protocol in the clinic. Accordingly, the patients were scheduled for check-ups after 1 year, 3 years, and 5 years. Recalls on an individual basis were used when indicated, and the patients contacted the clinic whenever they had problems with their prostheses.

Radiographic examinations were scheduled at prosthesis placement and at the 1- and 5-year check-ups using intraoral apical radiographs. Mean levels of marginal bone (mesial/distal) in relation to the fixture/abutment junction (FAJ) were assessed at each examination to the nearest 0.1 mm by two independent radiologists (bone level). A blinded technique was used for these measurements, that is, the two observers from the Department of Oral and Maxillofacial Radiology (Institute of Odontology, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden) were unaware if turned or TiUnite implants were evaluated. The marginal bone loss ("bone loss"/"bone resorption") was calculated as the difference between bone levels at two different radiographic examinations. Precision of measurements of marginal bone levels has been accounted for in other publications.[23,24]

TABLE 3 Life Table for Patients and Implants in the Mixed Group

	Number of Patients and Implants in the Mixed Group									
	Patients		TiUnite Implants				Turned Implants			
	Followed	Lost	Followed	Lost	Failed	CSR (%)	Followed	Lost	Failed	CSR (%)
Surgery	41		68			100	110			100
Prosthesis	41		66		2	97.1	110			100
1 year	38	3	62	4		97.1	101	9		100
5 years	33	5	53	9		97.1	85	15	1	99.1
Total	33	8	53	13	2	97.1	85	24	1	99.1

CSR is given in percentages.
CSR = cumulative survival rates.

TABLE 4 Life Table for Patients and Implants in the TiUnite Group

	Number of Patients and Implants in the TiUnite Group					
	Patients		Implants			
	Followed Up	Lost	Followed Up	Lost	Failed	CSR (%)
Surgery	70		212			100
Prosthesis	69	1	208	2	2	99.1
1 year	62	7	179	29		99.1
5 years	50	12	142	36	1	98.4
Total	50	20	142	67	3	98.4

CSR is given in percentages.
CSR = cumulative survival rates.

Statistics

Descriptive statistics and life table analyses presenting implant cumulative survival rates (CSRs) were utilized.

One turned implant and one TiUnite implant per patient of the mixed group were selected by random for statistical comparisons. Student's *t*-test for paired observations was used for these calculations with regard to marginal bone level and bone loss. Failure rates between test and control groups were compared by means of the chi-square test (Patients "with"/"without" failure). All statistics were performed on patient level and conducted at 5% significance level.

RESULTS

Withdrawals

Altogether, 27 of the patients (24%) provided with 104 implants were lost to follow-up and accordingly withdrew during the 5 years of follow-up (see Tables 3 and 4). Seven of these patients were deceased, 3 patients had moved, 4 patients were unable to come, and the remaining 13 patients were noncompliant.

TABLE 5 Distribution of Implants in Percentage with Regard to Implant Length (mm) for Both Groups

Implant Length (mm)	Distribution of Implants (%)		
	Mixed Group		TiUnite Group
	Turned	TiUnite	TiUnite
7	8.1	14.5	5.7
8.5	1.8	10.1	3.8
10	9.0	15.9	6.7
11.5	3.6	2.9	11.5
13	15.3	17.4	7.7
15	40.5	27.5	25.4
18	21.6	11.6	39.2

Implants

In the mixed group, the TiUnite implants were used in more compromised sites and, hence, proportionally more short implants were placed with this surface as compared with the turned implants in the same patients as well as compared with the TiUnite implants of the second group (see Table 5). The TiUnite implants of the mixed group were also more frequently placed in posterior positions (Table 6) and in sites of osteoporosis-like bone, while the TiUnite implants of the second group were more evenly distributed throughout the various jaw regions accordingly, probably placed in more favorable sites (see Table 6).

Altogether, six implants were lost during the follow-up period. Accordingly, one turned and two TiUnite implants in the mixed group and three implants of the TiUnite group were removed during the study period. The 5-year implant CSRs for the different groups are presented in Tables 3 and 4.

Prostheses and Maintenance

All prostheses remained stable throughout the study period and, thus, revealed a prosthesis CSR of 100%. Altogether, 65 of 83 patients (78.3%) presented a clinical situation with no problems or adjustments of their prostheses during 5 years in function.

Two abutment screws fractured and were replaced in two TiUnite group patients. Another two patients in the mixed group had loose prosthetic screws that were retightened. One patient presented fractures of the resin veneers.

TABLE 6 Distributions of Implants with Regard to Positions in the Quadrant of the Jaw. "Central" Implants are Placed Closest to the Midline, Followed by Implants in Position No. 2, No. 3, and No. 4, Respectively

	Distribution of Implant with Regard to Position			
Implants	Central	No. 2	No. 3	No. 4
Mixed group				
TiUnite	10.3	33.8	47.1	8.8
Turned	52.7	34.5	12.7	
TiUnite group				
TiUnite	50.0	32.5	16.5	0.9

The remaining comments and problems reported in the two groups were mainly related to oral maintenance and mucosal inflammations. Accordingly, one patient had re-instruction in oral maintenance in the mixed group, while maintenance and mucosal problems were noted in five patients in the TiUnite group. Two of these patients presented fistulae, both in connection to single implant restorations.

Radiographic Data

The marginal bone levels in relation to the FAJ at implant placement, at the 1- and the 5-year examinations, were almost identical for the turned and TiUnite implants of the mixed group (Table 7). Further, no statistically significant difference ($p > .5$) was found when comparing the corresponding data between the two implant surfaces in the mixed group (see Table 7). Thus, the mean loss of marginal bone during the whole study period did not differ significantly ($p > .5$) between the two implant types in the mixed group (Table 8), and neither was there any obvious difference between the implants of the two patient groups (see Table 8). Also, frequency distributions of all followed up implants based on the various intervals of marginal bone loss for

TABLE 7 Mean Marginal Bone Levels in mm for Turned and TiUnite (TiU-M) Implants in the Mixed Group and TiUnite Implants (TiU) in the TiUnite Group at Prosthesis *Placement* (Baseline) and After 1 Year and 5 Years in Function. Numbers of Individual Implants with Regard to Bone Levels at Different Time Intervals are Also Given

	Bone Levels in Relation to FAJ*								
	Placement			After 1 Year			After 5 Years		
	Turned	TiU-M	TiU	Turned	TiU-M	TiU	Turned	TiU-M	TiU
Patients	37	37	58	32	32	53	33	33	42
Implants	103	60	176	86	52	153	88	52	133
	Mean Marginal Bone Level (mm)								
Mean	1.4	1.4	1.2	2.0	2.0	1.8	2.1	2.0	1.8
SD	0.84	0.84	0.80	1.19	1.21	0.68	0.72	0.78	0.88
mm – (thread)	Distribution of Number of Implants								
≥0.0 (FAJ)	31	17	85	7	9	34	5	8	24
1.9 – (1st)	43	26	65	38	23	68	36	15	71
2.5 – (2nd)	17	10	9	19	6	33	25	17	16
3.1 – (3rd)	6	1	9	10	6	14	10	4	16
3.7 – (4th)	3	2	2	7	1	2	4	5	3
4.3 – (5th)	1	3	2	3	1	1	5	1	1
>4.3	2	1	4	2	6	1	1	2	2

*FAJ = fixture/abutment junction.

TABLE 8 Mean Marginal Bone Loss in mm for Turned and TiUnite (TiU-M) Implants in the Mixed Group and TiUnite Implants (TiU) in the TiUnite Group from Baseline to First (0–1 Year) and Fifth (0–5 Years) Years in Function, and from First to Fifth (1–5 years) Years in Function, Respectivley. Distributions of Individual Implants with Regard to Amount of Bone Loss during Different Time Intervals are Also Given

	Bone Loss during Follow-Up								
	0 to 1 Year			1 to 5 Years			0 to 5 Years		
	Turned	TiU-M	TiU	Turned	TiU-M	TiU	Turned	TiU-M	TiU
Patients	31	31	49	28	28	45	32	32	45
Implants	84	51	148	72	45	122	85	51	129
	Mean Marginal Bone Loss (mm)								
Mean	–0.6	–0.4	–0.6	–0.1	–0.3	–0.2	–0.6	–0.7	–0.8
SD	0.88	0.63	0.66	0.57	0.95	0.68	0.84	1.00	0.93
Bone loss (mm)	Distribution of Number of Implants								
0.0	19	21	52	37	22	61	22	13	39
0.1–0.6	32	13	48	21	15	33	26	16	31
0.7–1.2	16	9	32	9	5	22	17	9	33
1.3–1.8	10	6	11	3	2	4	10	10	18
1.9–2.4	2	1	4	1	—	1	5	1	4
2.5–3.0	3	—	—	—	—	—	2	—	1
>3.1	2	1	1	1	1	1	3	2	3

the time periods from placement to 1 year of follow-up, and from 1 year to 5 years of follow-up, are shown in Table 8. The same table shows that the prevalence figures of implants with pronounced bone loss were low and comparable.

When comparing patients with more bone loss at individual implants in the mixed group, it could be observed that these implants were distributed between different patients. Six implants, observed in three different patients, lost more than 2.5 mm (Table 8) during the first year in function (five turned, one TiUnite), as observed in three different patients. Three of these implants were found in one patient (two turned, one TiUnite), two in another, and one implant in a third patient, indicating a tendency of clustering. Seven implants were found with more than 2.5 mm bone loss for the entire follow-up period of 5 years in the mixed group (five turned, two TiUnite). These implants were placed in six different patients. Two of the implants were the same for the two time intervals.

DISCUSSION

The present investigation was designed as a retrospective study, where data were collected after 5 years of function. The clinical evidence of such an approach can be considered as weaker as compared with a more strict prospective study using a randomized control design. However, all patients in the present clinic are treated and followed up in accordance to strict clinical and radiographic procedures, where the intention is to allow for well-controlled quality assessments of any important changes of the clinical procedure. Thus, according to the structure of the clinic, it was the intention from the start to "quality control" the introduction of the new surface of the implant (TiUnite) after a period of time and to compare it with the performance of the established "basic" protocol (i.e., the turned surface). The present study protocol allows for more patients than is usual for a prospective study, but with the price of lower stringency than a strict randomized clinical trial study can offer. This study was based on the pre-established clinical protocols and a step-by-step introduction of the new surface, in selected cases at first and later followed by a broader use. The study cannot be classified as a "true" prospective study, but not as a "true" retrospective study either. Instead, it can be considered as a transition between a retrospective study with a prospective character and a prospective study with a retrospective character, allowing for clinical evidence somewhere in between the two alternates. Accordingly, the present study does not allow for a strict prospective comparison between two surfaces using a randomized placement of

implants, but it allows for a comparison between surfaces where TiUnite implants have been placed in more compromised sites in the same patient (mixed group). A randomized selection of one implant surface each in the same patient provides with some randomization, where the TiUnite group can be used to support the observations made from the comparison in the mixed group.

The number of patients withdrawn from the present study reached 24%, which is a somewhat high figure. Apart from the deceased, the majority of these patients was contacted by the investigators and was offered a follow-up visit. Although not admitting any subjective problems with their implant constructions, these patients did not turn up for a clinical and radiographic examination because of severe illness, because they had moved, or they were just noncompliant.

Patients of the mixed group received both turned and TiUnite implants, and CSRs at 5 years were 99.1% and 97.1%, respectively. The result is in accordance with the ones reported after 3 years to 5 years of clinical use with TiUnite implants.[11–13] It is noteworthy that, in the mixed group, 38 out of 43 prostheses were placed in the maxillae with frequently compromised bone qualities and quantities as compared with mandibles. Further, it is noteworthy that the TiUnite implants of the mixed group were selected by the surgeon to be seated in the most compromised sites, that is, in regions of poor bone volume and soft bone quality.[21] This is also reflected in Tables 5 and 6, showing that the TiUnite implants of the mixed group were more often shorter (7–8.5 mm) and placed in more posterior positions as compared with the turned ones. Hence, under such circumstances, the present survival rate of 97.1% at 5 years with TiUnite implants is most encouraging.

The 5-year outcome of 98.4% of the TiUnite implants in the second group is also most favorable. Here, the jaw distribution revealed a higher representation of single-tooth reconstructions and of mandibles of less complicated character. The percentage of long TiUnite implants (15 mm and 18 mm) was much higher (65%) than the corresponding one of the mixed group (39%), and the proportion of implants placed in the soft bone quality 4[21] was less in the TiUnite group (15.6%) than in the mixed group (41.2%). Thus, the preconditions for a successful outcome of the implants in the TiUnite group were better than the TiUnite ones in the mixed group, for, as shown by, for example, Herrmann and colleagues,[25] patients with resorbed jaws and soft bone quality have a statistically higher risk for implant failure.

None of the 34 single-tooth implants was lost and neither was there a cluster of implant loss in any patient, the reason why all prostheses remained stable during the whole study period.

Mean values of the marginal bone level for the different groups and implants at 1 year are in accordance with those reported for TiUnite implants at 1 year under similar conditions,[5,26] and the 5-year figures are in conformity with data reported for the same time period by Glausser and colleagues.[13] The mean marginal bone resorption for the TiUnite implants of 0.4 mm to 0.6 mm at the 1-year check-up and of 0.7 mm to 0.8 mm at the 5-year check-up was also comparable to previous findings.[1–6,11–13]

No statistical differences could be found in the present investigation when comparing values of marginal bone level and marginal bone resorption around turned and TiUnite implants at 1 year and 5 years of function between the randomly selected implants in the mixed group. This is also in agreement with previous findings.[12,17,19] Moreover, frequency distributions of implants with bone loss of 2 mm or more did not reveal any obvious difference between the two surfaces, and the prevalence of implants with such defects was low for both types. In a dog study by Albouy and colleagues,[16] it was reported significantly more bone resorption at implants with the TiUnite surface as compared with another commercially available implant surface. A total of four implant surfaces were tested, and all developed ligature-induced defects. The spontaneous progression of bone loss was measured during the subsequent plaque accumulation period. However, obvious differences could be observed in the given tables between the implants at baseline,[16] indicating a very similar total average bone level for all the medium rough implants at the termination of the study. Nevertheless, concluding observations in this animal study are not supported in the present long-term clinical study, indicating similar bone reactions around the two different implant surfaces in clinical use (see Table 8). The lack of consistency between experimental animal studies and clinical follow-up studies is one reason for why most of the established Health Technology Assessment centers worldwide do not use animal studies as support for their clinical evidence statements.

Registered soft tissue involvements with maintenance problems, mucositis, fistulae, and pus formation were few for the two implant types (six patients/5.4%). Whether this is an expression for that the TiUnite surface over time behaves similarly (or better) as the turned one, is the result of a too short observation period, or is just coincidental is not possible to state. Little is known of the long-term outcome of moderately rough surfaces, although in a study by Rasmusson and colleagues,[27] TiOblast™ implants (Astra Tech AB, Mölndal, Sweden) were followed up with radiographs for 7 years and with clinical examinations for 10 years. During this period, no increase in progressive bone loss or peri-implantitis was reported. However, moderately rough surfaces differ from each other, and one should not extrapolate too much from the data of other implant surfaces. Albeit, the clinical and radiographic outcomes of the present study were most favorable at 5 years; longer follow-up periods, covering larger groups of patients, are needed to evaluate the TiUnite surface.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. [Correction added after online publication 24 May 2010: Conflict of Interest Statement added.]

REFERENCES

1. Glauser R, Lundgren AK, Gottlow J, et al. Immediate occlusal loading of Brånemark TiUnite implants placed predominantly in soft bone: 1-year results of a prospective clinical study. Clin Implant Dent Relat Res 2003; 5(Suppl 1):47–56.
2. Calandriello R, Tomatis M. Immediate function of single implants using Brånemark System®: prospective one year report of final restorations. Appl Osseointegration Res 2004; 4:32–40.
3. Vanden Bogaerde L, Pedretti G, Dellacasa P, Mozzati M, Rangert B, Wendelhag I. Early function of splinted implants in maxillas and posterior mandibles, using Brånemark System TiUnite™ implants: an 18-month prospective clinical multicenter study. Clin Implant Dent Relat Res 2004; 6:121–129.
4. Friberg B, Dahlin C, Widmark G, Östman P-O, Billström C. One-year results of a prospective multicenter study on Brånemark System® implants with a TiUnite™ surface. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S70–S75.
5. Östman P-O, Hellman M, Sennerby L. Direct implant loading in the edentulous maxilla using a bone density-adapted surgical protocol and primary implant stability criteria for inclusion. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S60–S69.
6. Renouard F, Nisand D. Short implants in the severely resorbed maxilla: a 2-year retrospective clinical study. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S104–S110.
7. Vanden Bogaerde L, Rangert B, Wendelhag I. Immediate/early function of Brånemark System® TiUnite™ implants in fresh extraction sockets in maxillae and posterior mandibles: an 18-month prospective clinical study. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S121–S130.
8. Villa R, Rangert B. Early loading of interforaminal implants immediately installed after extraction of teeth presenting endodontic and periodontal lesions. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S28–S35.
9. Brechter M, Nilson H, Lundgren S. Oxidized titanium implants in reconstructive jaw surgery. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S83–S87.
10. Holmquist P, Dasmah A, Sennerby L, Hallman M. A new technique for reconstruction of the atrophied narrow alveolar crest in the maxilla using morselized impacted bone allograft and later placement of dental implants. Clin Implant Dent Relat Res 2008; 10:86–92.
11. Degidi M, Perrotti V, Piattelli A. Immediately loaded titanium implants with a porous anodized surface with at least 36 months of follow-up. Clin Implant Dent Relat Res 2006; 8:169–177.
12. Östman P-O, Hellman M, Sennerby L. Immediate occlusal loading of implants in the partially edentate mandible: a prospective 1-year radiographic and 4-year clinical study. Int J Oral Maxillofac Implants 2008; 23:315–322.
13. Glauser R, Zembic A, Ruhstaller P, Windisch S. Five-year results of implants with an oxidized surface placed predominantly in soft quality bone and subjected to immediate loading. J Prosthet Dent 2007; 97:S59–S68, erratum in J Prosthet Dent 2008; 99:167.
14. Jemt T, Lekholm U. Implant treatment in edentulous maxillae: a 5-year follow-up report on patients with different degrees of jaw resorption. Int J Oral Maxillofac Implants 1995; 10:303–311.
15. Friberg B, Henningsson C, Jemt T. Rehabilitation of edentulous mandibles by means of turned Brånemark System® implants after one-stage surgery: a 1-year retrospective study of 152 patients. Clin Implant Dent Relat Res 2005; 7:1–9.

16. Albouy J-P, Abrahamsson I, Person LG, Berglundh T. Spontaneous progression of peri-implantitis at different types of implants. An experimental study in dogs. I: clinical and radiographic observations. Clin Oral Implants Res 2008; 19:997–1002.
17. Rocci A, Martignoni M, Gottlow J. Immediate loading of Brånemark System TiUnite and machined-surface implants in the posterior mandible: a randomized open-ended clinical trial. Clin Implant Dent Relat Res 2003; 5(Suppl 1):S57–S63.
18. Balshi SF, Wolfinger GJ, Balshi TJ. Analysis of 164 titanium oxide-surface implants in completely edentulous arches for fixed prosthesis anchorage using the pterygomaxillary region. Int J Oral Maxillofac Implants 2005; 20:946–952.
19. Friberg B, Jemt T. Rehabilitation of edentulous mandibles by means of 5 TiUnite implants after one stage surgery: a 1-year retrospective study on 90 patients. Clin Implant Dent Relat Res 2008; 10:47–54.
20. Jungner M, Lundqvist P, Lundgren S. Oxidized titanium implants (Nobel Biocare TiUnite) compared with turned titanium implants (Nobel Biocare Mark III) with respect to implant failure in a group of consecutive patients treated with early functional loading and two-stage protocol. Clin Oral Implants Res 2005; 16:308–312.
21. Lekholm U, Zarb GA. Patient selection and preparation. In: Brånemark P-I, Zarb GA, Albrektsson T, eds. Tissue-integrated prostheses: osseointegration in clinical dentistry. Chicago, IL: Quintessence Publ Co, 1985:199–209.
22. Widmark G, Friberg B, Johansson B, Sindet-Pedersen S, Taylor Å. Mk III: a third generation of the self-tapping Brånemark System® implant, including the new Stargrip™ internal grip design. A 1-year prospective four-center study. Clin Implant Dent Relat Res 2003; 5:273–279.
23. Gröndahl K, Sundén S, Gröndahl H-G. Inter-and intraobserver variability in radiographic bone level assessment at Brånemark fixtures. Clin Oral Implants Res 1998; 9:243–250.
24. Pikner-Sundén S. Radiographic follow-up analysis of Brånemark dental implants. Swed Dent J Suppl 2008; 194:5–69, 2.
25. Herrmann I, Kultje C, Holm S, Lekholm U. A study on variances in multivariate analyses of oral implant outcome. Clin Implant Dent Relat Res 2007; 9:6–14.
26. Malo P, Rangert B, Nobre M. All-on-4 immediate-function concept with Brånemark System® implants for completely edentulous maxillae: a 1-year retrospective clinical study. Clin Implant Dent Relat Res 2005; 7(Suppl 1):S88–S94.
27. Rasmusson L, Roos J, Bystedt H. A 10-year follow-up study of titanium dioxide-blasted implants. Clin Implant Dent Relat Res 2005; 7:36–42.