A Retrospective Comparison of Oxidized and Turned Implants with Respect to Implant Survival, Marginal Bone Level and Peri-Implant Soft Tissue Conditions after at Least 5 Years in Function

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ABSTRACT

Background: Long-term clinical follow-up studies comparing different implant surfaces with regard to survival and marginal conditions are rare.

Objectives: The objective of this study was to compare the clinical performance of turned and oxidized implants after more than 5 years of loading

Material and Methods: One hundred three patients (43 men, 60 women; mean age 67.4 years, range 32–90) previously treated with 287 implants (Nobel Biocare AB, Gothenburg, Sweden), 133 with turned surface (MKIII, Nobel Biocare AB) and 154 with an oxidized surface (MKIII, TiUnite, Nobel Biocare AB) were examined after at least 5 years of loading (mean 82 months, range 60–93 months). The implants had been used for support of single crowns (33 patients/36 implants), partial bridges (39 patients/103 implants), or full bridges (31 patients/148 implants) following an early loading protocol (14 patients /54 implants), a one-stage protocol (32 patients/59 implants) or a two-stage protocol (57 patients/174 implants). Clinical examinations of bleeding on probing (BoP) and pocket depth (PD) were performed. Intraoral radiographs were used for assessments of marginal bone levels (MBLs).

Results: Seven turned implants and one oxidized implant failed, giving overall cumulative survival rates of 94.7 and 99.4%, respectively. There were no differences for BoP scores (0.5 ± 0.7 vs 0.4 ± 0.6) and PD measurements (1.7 ± 0.8 mm vs 1.8 ± 1.0 mm) parameters when comparing turned and oxidized implants, respectively. The mean MBL was 1.8 ± 0.8 mm and 2.0 ± 0.9 mm for turned and oxidized implants, respectively, after more than 5 years in function (NS). Frequency distribution of MBL loss showed no statistically significant differences between the two surfaces. A total of four implants (1.4%) (three oxidized and one turned) showed a PD > 3 mm, MBL > 4 mm, and BoP. However, none of these were associated with suppuration on examination.

Conclusion: The present study does not state any differences in implant failure, MBL, presence of bleeding or PD around implants when comparing turned and oxidized titanium implants after at least 5 years of function.

KEY WORDS: dental implants, implant survival, long term, oxidized surface, surface characterization, turned surface

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INTRODUCTION

Dental implants ad modum Brånemark have been used for prosthetic reconstruction of edentulous patients for over 45 years. The original Brånemark implant had a turned and minimally rough surface, while implants with an oxidized moderately rough surface topography (TiUnite, Nobel Biocare AB, Gothenburg, Sweden) have been available for more than 10 years. Long-term follow-up studies on the original surface have reported encouraging results with high survival rates and steady marginal bone levels (MBLs).[1–3] Up to about 1.5 mm of marginal bone (to the first thread) is usually remodeled during the first year of function,[4] where after many studies have shown only minor changes of the average MBL.[5] However, some patients and implants show more and sometime continuous bone loss, which may lead to soft tissue problems and loss of the implant. The mechanisms behind such bone loss are most likely multifactorial and may be explained by remodeling as part of implant healing, the response to loading, ongoing atrophy after tooth loss, infection, or by other factors. Studies have analyzed the prevalence of ongoing MBL loss and reported that 7.7 to 21% of turned Brånemark implants to be affected after up to 5 years of follow-up.[6,7] Short-term clinical studies on oxidized Brånemark implants have demonstrated good clinical outcomes and have even indicated better survival rates than turned implants, especially in immediate loading[8,9] and bone grafting situations.[10] Clinical follow-up studies have also shown no apparent differences between turned and oxidized implants with regard to MBL loss.[11] In spite of this, concerns have been raised that long-term use of oxidized implants may result in more peri-implant pathology than previously seen around turned implants. For instance, authors have noted more bone loss at oxidized as compared with other surface-modified implants in an experimental dog model using cotton ligature-induced MBL loss.[12,13] Moreover, clinical studies[14] on an oxidized one-piece implant used for immediate loading reported early and extensive MBL loss, which resulted in implant failure. However, the relevance of the results from the dog model and from the one-piece implant studies on the long-term clinical function of oxidized Brånemark implants can be seriously questioned. Hence, more clinical studies documenting the long-term function of oxidized Brånemark implants are needed.

The aim of the present retrospective study was to compare the clinical performance of turned and oxidized implants after more than 5 years of loading with regard to survival rate, MBL, and peri-implant soft tissue conditions.

MATERIALS AND METHODS

Patients

The patient charts of consecutive implant treatments between January 2001 and December 2002 in one clinic were evaluated to find subjects suitable for the present retrospective study. The inclusion criteria were: (1) previous treatment with turned and/or oxidized dental implants for replacement of one or several missing teeth; (2) implants placed with no bone augmentation procedure; (3) followed for at least 5 years in function; and (4) giving written consent to participate in the study. A total of 136 consecutive patients[15] were found to meet with the inclusion criteria. Eight patients had deceased and 128 were invited. All patients were informed about the study and follow-up and could withdraw from the study at any time. Twenty-five patients refrained from participating in the study, resulting in that 103 patients were included. The 25 patients who refrained to participate were contacted by telephone and interviewed with respect to their present situation due to their previous oral implant treatment. The principles of the declaration of Helsinki were followed.

The study group of 103 patients (43 men, 60 women; mean age 67.4 years, range 32–90) had been treated with 287 implants (Nobel Biocare AB), 133 with turned surface (MKIII, Nobel Biocare AB) and 154 with an oxidized surface (MKIII, TiUnite). Eighteen of the patients were smokers. The implants had been used for support of single crowns (33 patients/36 implants), partial bridges (39 patients/103 implants), or full bridges (31 patients/148 implants) (Table 1) following an early loading protocol (loading within 25 days, range 13–32 days) (14 patients/54 implants), an one-stage protocol (32 patients/59 implants) or a two-stage protocol (57 patients/174 implants) (see Table 1) The one- and two-stage groups had a mean healing time of 17 weeks (range 4–36 weeks) before prosthetic treatment.

The characteristics of the dropout patients are described in Table 2.

Maintenance Protocol

Two weeks after crown and bridge delivery, gold screws where retighten and the passages permanently closed with composite resin. Three months after delivery, the patients had been scheduled for professional cleaning and instruction in oral hygiene. At this occasion, occlusion, articulation, phonetics, and the patient's subjective estimation were examined. Patients with need for professional hygiene support due to poor oral hygiene were scheduled to a dental hygienist every third month. All patients were seen to the first annual checkup. As most of the patients had been referred, follow-ups after the first annual checkup were performed at the referring clinic.

TABLE 1 Distribution of Patients and Implants (5-Year Follow-Up)

	Oxidized Surface		Turned Surface		Total	
	Patients	Implants	Patients	Implants	Patients	Implants
Male	24	82	19	61	43	143
Female	31	72	29	72	60	144
Full arch	15	73	16	75	31	148
Partial	24	62	15	41	39	103
Single	16	19	17	17	33	36
Early loading	7	26	7	28	14	54
One stage	25	48	7	11	32	59
Two stage	23	80	34	94	57	174
Smokers	13	42	5	18	18	60
Non-smokers	42	112	43	115	85	227
Total	55	154	48	133	103	287

TABLE 2 Specification of Dropout Patients

Gender	Age (Years)	Surface	Position	Implants (*n*)	Implant Length (mm)
Female	54	Oxidized	44,45,46	3	2 × 13, 10
Female	71	Oxidized	15,16	2	2 × 13
Female	70	Oxidized	41,31,32,34	4	4 × 13
Female	74	Oxidized	14,15,16	3	2 × 13, 10
Female	65	Oxidized	Full arch maxilla	6	6 × 10
Male	85	Oxidized	Full arch mandible	4	4 × 15
Male	32	Oxidized	21	1	13
Male	64	Oxidized	23,24	2	15, 10
Male	60	Oxidized	Full arch maxilla	6	6 × 15
Male	45	Oxidized	11	1	13
Female	61	Turned	Full arch mandible	4	4 × 13
Female	87	Turned	Full arch mandible	4	4 × 15
Female	41	Turned	36	1	10
Female	74	Turned	24,25	2	15,10
Female	71	Turned	23,25	2	2 × 13
Female	68	Turned	Full arch maxilla	6	4 × 13, 2 × 15
Female	52	Turned	Full arch maxilla	6	3 × 15, 2 × 13, 10
Female	69	Turned	11,21,23,25	4	3 × 13, 10
Female	60	Turned	Full arch mandible	4	3 × 15, 13
Male	82	Turned	34,36,44,46	4	2 × 13, 2 × 10
Male	21	Turned	46	1	13
Male	56	Turned	11	1	13
Male	82	Turned	23,24,25	3	2 × 13, 10
Male	68	Turned	11,12	2	2 × 13
Male	83	Turned	Full arch maxilla	6	6 × 13

Clinical and Radiographic Examinations

The patients were clinically and radiographically examined at one occasion after more than 5 years in function by two clinicians (PL and MJ). A standardized protocol was used and comprised the following parameters: (1) bleeding on probing (BoP) at mesial and distal aspects of each implant (0 = no bleeding, 1 = bleeding at one surface, 2 = bleeding at two surfaces); (2) pocket depth (PD) in millimeters at distal and mesial aspects of each implant; and (3) MBL in intraoral radiographs (Planmeca Oy, Helsinki, Finland). The same investigator, using a dental probe, performed all the examinations regarding the PD. The distance from the implant platform to the first bone contact was measured in tenth of millimeters at distal and mesial aspects of each implant using a computer-based software (OsiriX 3.6.1 32-bit running on OSX 10.6.3, Pixmeo SARL, Bernex, Switzerland). Each radiograph was calibrated by using the known length of the implant as reference (Figure 1). A mean value was calculated for each implant.

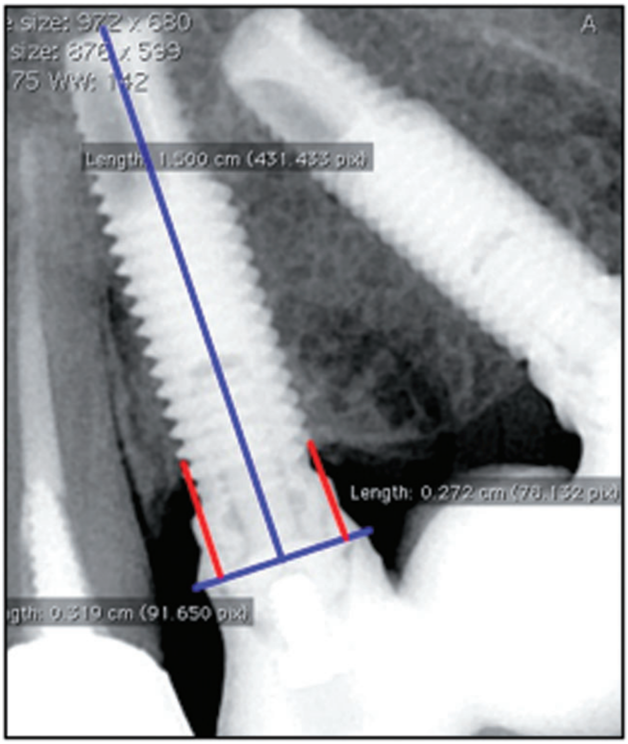

Figure 1 Each radiograph was calibrated by using the known length of the implant as reference.

Failure and Survival Criteria

An implant removed for any reason was regarded as a failure, while all other implants were regarded as survivals.

Statistics

All results were analyzed using a statistic software (SPSS Statistics 17.0, IBM, New York, NY, USA). One-way ANOVA tests were used for comparisons between turned and oxidized implants and between the different loading protocols. A statistically significant difference was considered if p value $\leq .05$.

RESULTS

Implant Failure

A total of eight implant failures were registered in six patients (three male, three female) from placement to the last follow-up: seven with turned surface and one with oxidized surface. The overall cumulative survival rates were 94.7% for turned and 99.4% for oxidized implants. All turned surface implants had been inserted following a two-stage protocol and were lost during the first year in function: six in the maxilla and one in the mandible. Two of the failures occurred prior to loading and five implants after a mean loading time of 23 weeks (range 7–40 weeks). One maxillary oxidized implant inserted following a one-stage protocol was lost after 4 years of loading due to infection and marginal bone loss (Table 3).

TABLE 3 Specification of Lost Implants

Gender	Age (Years)	Surface	Position	Implants Lost (*n*)	Length (mm)	Time of Loss (Months)
Male	76	Turned	21	1	13	6
Female	61	Turned	25	1	15	6
Male	56	Turned	12, 11, 22	3	15, 15, 13	16
Female	62	Turned	44	1	13	5
Female	45	Turned	25	1	10	10
Female	66	Oxidized	15	1	13	51

TABLE 4 Descriptives of Marginal Bone Level in Relation to Surfaces

	Oxidized Surface (TiUnite)				Turned Surface (Mark III)			
Type and Location	Mean	SD	Min	Max	Mean	SD	Min	Max
Overall marginal bone level (mm)	2.0	0.9	0.2	5.5	1.8	0.8	0.6	5.6
Bleeding on probing (index)	0.4	0.6	0,0	2.0	0.5	0.7	0,0	2.0
Pocket depth (mm)	1.8	1.0	1.0	5.7	1.7	0.8	1.0	3.8
Marginal bone level in relation to location (mm)								
Full arch	2.2	1.0	1.4	5.4	2.0	0.3	1.4	2.5
Partial	2.2	0.9	1.0	5.4	2.1	1.2	1.1	5.6
Single	1.5	0.6	0.2	5.4	1.3	0.5	0.6	5.6
Marginal bone level in relation to loading protocol (mm)								
Early loading	2.0	0.5	1.6	2.9	2.1	0.3	1.6	2.5
One stage	1.8	1.0	0.2	5.4	1.6	0.5	0.8	2.2
Two stage	2.3	0.9	1.3	5.4	1.8	0.9	0.6	5.6
Marginal bone level in relation to smoking habits (mm)								
Smokers	2.5	1.1	1.2	5.4	1.7	0.7	0.7	2.2
Non-smokers	1.9	0.8	0.2	5.4	1.8	0.8	0.6	5.6

Soft Tissue Health

BoP was recorded in 28 out of 133 turned implants (21%) and in 34 out of 154 oxidized implants (22%). There were no differences for BoP scores (0.5 ± 0.7 vs 0.4 ± 0.6) and PD measurements (1.7 ± 0.8 vs 1.8 ± 1.0 mm) when comparing turned and oxidized implants, respectively (Table 4). Neither were there any differences when comparing BoP scores and PD measurements between the different loading protocols. Four implants (1.4%) (three oxidized and one turned) showed PD > 3 mm, MBL > 4 mm, and BoP. However, none of these were associated with suppuration on examination. The lost maxillary oxidized implant in a 66-year-old woman, was at time of removal shoving signs of soft tissue infection with pus present.

MBL

The mean MBL was positioned 1.8 ± 0.8 and 2.0 ± 0.9 mm below the implant abutment junction for turned and oxidized implants, respectively after more than five years in function (see Table 4). The difference was not statistically significant.

Frequency distribution of marginal bone loss showed no statistically significant differences between the two surfaces, although more oxidized implants presented a MBL of more than 3 mm below the implant abutment junction (Figure 2). There was no correlation between BoP and MBL.

Smokers with oxidized implants showed significantly more bone loss than non-smokers ($p = .046$). No differences were seen between smokers and non-smokers in the turned implant group. No differences in MBL could be seen between loading protocols used.

Dropout Patients

None of the 25 dropout patients, after contacted by telephone, declared any loss of implants after their last clinical follow-up, presence of pain, or other dysfunction associated with their implant treatment. The characteristics of the dropout patients are described in (see Table 2).

DISCUSSION

The aim of the present retrospective investigation was to study possible differences in clinical performance of dental implants with either a turned or an oxidized surface (TiUnite) in terms of survival, MBL, and soft tissue health at the implant sites. The study was performed on a consecutive group of 136 patients treated between January 2001 and December 2002, whom where invited for a follow-up examination after more than 5 years in function. There was a patient dropout rate of 18% due to death, health problems, geographic distance, or refusal to participate in the study, which is similar to what have been reported for other 5-year reports. As for many retrospective reports, an obvious

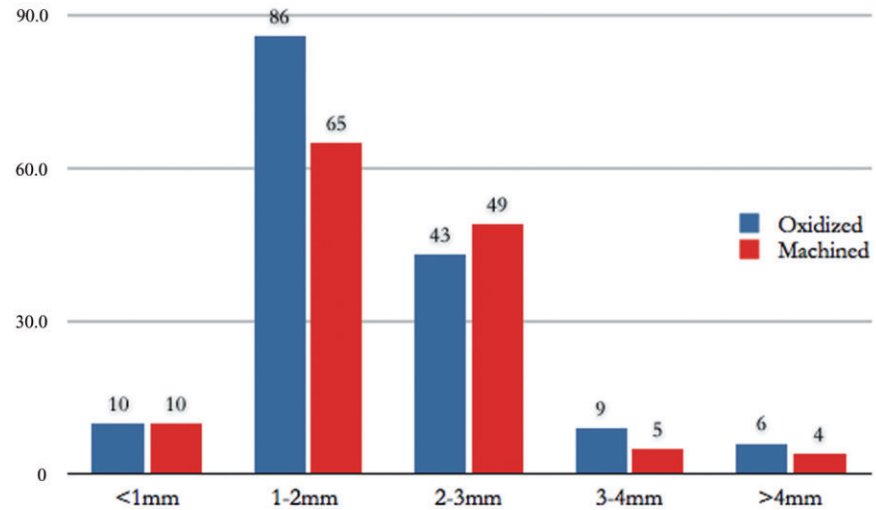

Figure 2 Frequency distribution of marginal bone level between the two surfaces.

weakness of the present study is the lack of baseline radiographs, which made it impossible to calculate MBL loss. Instead, the analysis was based on the position of the MBL in the last follow-up radiograph. If assuming that all implants were submerged in bone, the baseline level would theoretically have been in level with the prosthetic platform and bone level data from the follow-up would then reflect true marginal bone loss. However, some implants were probably not fully submerged, which means less bone loss than what the bone level data would suggest. Thus, one drawback is that bone level data cannot be compared with marginal bone loss data published in other studies. Nevertheless, bone level data can be looked upon as a worst-case scenario.

During the first year after surgical insertion, seven turned implants were lost in five patients: two prior to loading and five after loading has commenced. Only one oxidized implant was lost during the follow-up (after 4 years in function), giving an overall cumulative survival rate of 99.4% for the oxidized surface and 94.7% for the turned implants. Although the difference was not statistically significant, our results corroborate with other studies where more turned implants than oxidized seems to be lost during the follow-up.[16] In a series of publication, Glauser and colleagues[17] reported an implant success rate of 97.1% for oxidized implants after 1 year when used for an immediate loading protocol. In a 5-year cross-sectional, retrospective follow-up study, Friberg and Jemt[18] described a 5-year cumulative survival rate of 97.1% for turned and 98.4% for oxidized (TiUnite) implants. In a long-term study, Roos-Jansaker and colleagues[19] reported a survival rate of 95.7% for 1,057 turned titanium implants after 9 to 14 years of loading. The authors noted that implant losses clustered in a few patients and early failures were most common, a tendency which is in accordance to the present study. Friberg and Jemt used the TiUnite implants in more compromised sites and, hence proportionally more short implants were placed with oxidized surface as compared with the turned implants in the same patients as well as compared with the TiUnite only implants group. The TiUnite implants of the mixed group were also more frequently placed in posterior positions and in sites of osteoporosis-like bone, while the TiUnite implants of the second group (only TiUnite) were more evenly distributed throughout the various jaw regions accordingly.[18]

In 2008, Jemt and Albrektsson[20] discussed the impact of different definitions of peri-implantitis on the outcomes of studies from other authors.[7] Albrektsson and Isidor[21] defined peri-implantitis as inflammation with loss of supporting bone in the tissues surrounding a functioning implant. According to this definition, any sign of bone loss (even <0.2 mm annually) with inflammation may be interpreted as indicative of peri-implantitis. Roos-Jansaker and colleagues[7] defines peri-implantitis as implants demonstrating BoP and/or pus combined with a total bone loss of 1.8 mm or more during 8 to 13 years following the first annual checkup.

Experimental[12,13] and clinical studies[14] have reported extensive marginal bone loss in conjunction with oxidized implant surfaces. However, a large number of follow-up studies have shown good conservation of the marginal tissue with no apparent differences compared with turned surfaces.[8,11,18] The clinical studies showing extensive bone loss was using a complete different one-piece implant design than the studies showing good marginal bone response, which can explain the different experiences.

The MBL at time of examination was on average located 2.0 mm below the prosthetic platform for oxidized implants (range 0.2–5.5 mm) and 1.8 mm for turned implants (range 0.6–5.6 mm), with no significant difference. Fröberg and colleagues[11] showed no significant differences regarding changes in MBL between a group of turned and oxidized implants during an 18-month follow-up period. Although the number of total implants has to be considered low ($n = 89$), the distribution of MBL changes around implants are very similar to our data. Contradictory to our findings, Roos-Jansaker and colleagues[7] reports 21% of the implants exhibiting more than 3.1 mm of marginal bone loss over a period of 9 to 14 years. Resembling data from our study suggests 9.7% of the oxidized implants and 6.9% of the turned implants presenting a MBL >3 mm at minimum 5 years; however, this difference might be larger, due to the fact that in the present study, the parameters measured was bone level (distance from the implant platform to the first bone contact) instead of marginal bone loss.

In the present study, smoking did not affect marginal bone loss at turned implants. In the oxidized group, however, there was a significant difference between smokers and non-smokers ($p = .046$), with more bone loss in smokers (mean difference –0.6 mm). A recently published paper[22] showed similar findings, indicating that smoking had negative effects on early bone tissue responses to oxidized implants as assessed by histomorphometry, suggesting a slower wound repair.

Achieving reliable measurements and values from intraoral radiographs, requires ortho-radial exposures, appropriate calibration procedures and accurate, homogeneous readouts. In a recent publication, intraobserver variation was found to be the largest source of the total variation when studying inter- and intraobserver variability of radiographic bone level assessments.[23,24] The authors also concluded that reliability of the measurements could improve by multiple readings by one observer, and even more, by letting several observers make several, independent readings. In the present study, one observer measured the digital radiographs, and an interindividual calibration was performed by another independent observer, with remeasuring 58 random surfaces (9.9%) of the total 574. The interindividual differences in measurements of MBL, between the two observers were analyzed with Wilcoxon signed-rank test as a nonparametric analyze showing no significant difference between the interexaminer measurements (p value = .88). The mean difference was 0.56 mm (range 0–1.9 mm, SD 0.42 mm, and variance 0.18 mm).

Different loading protocols of dental implants is widely described and investigated in other papers[25–27] and shorter healing times in favor for earlier functional loading are shown to have a predictable, clinical good outcome.[28,29]

Generally, the power and reliability for a prospective, randomized study, is considered higher, than the investigation here presented. Despite that, one has to take into consideration that the group of patients are, although consecutive, treated at the same clinic, with very few clinicians involved, all following a strict well-defined treatment protocol.

CONCLUSION

A higher but not statistically significant survival rate was found for oxidized than for turned implants, 99.4 versus 94.7%, after more than 5 years in function. No significant differences in MBL, PD, or BoP between turned and oxidized implants were seen. Four implants (1.4%) (three oxidized and one turned) showed PD > 3 mm, MBL > 4 mm, and BoP. However, none of these were associated with suppuration on examination.

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