The Importance of Implant Surface Characteristics in the Replacement of Failed Implants

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Purpose: *The purpose of the study was to compare the failure rates of implants with either a machined surface or a TiUnite surface used to replace failing implants.* ***Materials and Methods:*** *The files of 578 patients, ie, of all patients who were treated at the Department of Periodontology of the University Hospital in Leuven by means of oral implants during 3 recent consecutive years, were analyzed. The implants included in the study had an observation time ranging from 9 to 49 months. All patients had been provided with Brånemark System implants. Only 2 types of implant surfaces were used: machined and TiUnite. Data collection and analysis focused on the replacement implants, ie, implants placed at sites where the original implants had failed. Data were statistically analyzed by means of Statistica for Windows Software version 5.1; a Fisher exact* P *test was used. The level of significance was set at P = .05.* ***Results:*** *A total of 41 patients experienced the nonintegration of 58 implants. Of those, 29 implants with a machined surface were replaced by implants with the same surface. Six of the replacement implants failed. Nineteen machined-surface implants were replaced by TiUnite surface implants; 1 failed. Ten TiUnite-surface implants were replaced by implants with the same surface; none failed. The difference in failure rate between machined-surface replacement implants and TiUnite replacement implants was statistically significant (P = .05).* ***Discussion:*** *In addition to the usual patient-related compromising factors, replacement of a failing implant involves the challenge of achieving osseointegration in a nonpristine bone site. In the present study, implants with TiUnite surfaces were associated with fewer failures than machined-surface implants under the same conditions.* ***Conclusion:*** *An improved implant surface such as TiUnite may offer a better prognosis when a failed implant has to be replaced at the same site.* (Comparative Cohort Study) INT J ORAL MAXILLOFAC IMPLANTS 2006;21:270–274

Key words: *dental implants, implant failures, implant surfaces, osseointegration*

The use of oral endosseous implants to retain or to support a dental prosthesis is a well-established clinical procedure based on the principle of osseointegration.[1] This biologic principle was clinically introduced by P-I Brånemark approximately 4 decades ago. High success rates were reported on consecutive implants in the treatment of both full and partial edentulism and in both the maxilla and mandible. Lindquist and associates[2] reported a cumulative success rate of 98.9% for the Brånemark System after 15 years for edentulous patients provided with mandibular fixed prostheses.[3] The same patient group eventually included implants successful for more than 20 years in function, with a cumulative survival rate of 98.9%. Similar results were reported for implants retaining an overdenture, again in the symphyseal area.[4]

The rehabilitation of partially edentulous jaws originally seemed less successful in a multicenter retrospective study.[5] Later, it appeared that a learning curve played a certain role, since in a 10-year prospective multicenter study cumulative success rates of 90.2% for the maxilla and 93.7% for the mandible were reached.[6]

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All these results were achieved with commercially pure titanium screw-shaped implants with a machined surface (also called a turned surface). Recently, many implant surfaces have been developed using various reducing techniques such as blasting with aluminum oxide particles, grit-blasting with titanium dioxide particles, sandblasting and acid-etching, and acid-etching alone.[7–9] Increased oxidation of the implant surface has also been proposed.[10] The TiUnite implant (Brånemark System; Nobel Biocare, Göteborg, Sweden) surface is created by anodic oxidation. These modified surfaces have been proven to enhance and speed bone apposition.[11–15]

Early occlusal load may be imposed on implants with such modified surfaces, since bone apposition takes place at a faster rate.[16–18] Modified or so-called improved surfaces could also lead to increased success rates in patients or locations that do not offer optimal bone quality and quantity. For optimal situations, such as symphyseal areas, where success rates close to 100% have already been achieved, the need for improved surfaces can be questioned.[3]

Another development over the years has been the use of less elaborate surgical approaches, since clinicians with variable skills and training are now performing implant placement surgeries. Because today's implants are not being placed by a small pool of highly experienced clinicians, as the early experimental implants were, the variation in clinician skill and experience may need to be compensated for by an improved surface to obtain similarly predictable osseointegration. Aseptic surgery has been advocated since the early days.[19] The use of a nose guard to prevent contact of sterile gloves with the highly contaminated nasal skin is highly recommended.[20] Today these aspects are often overlooked; surgery is sometimes even performed in a nonsurgical setup. Furthermore, even when a less precise drilling trajectory is used or when drilling is performed without coolant, predictable bone apposition can still be achieved with implants with improved surfaces that trigger a more intense osteoblastic reaction.[21] Lazzara and associates[21] demonstrated histomorphometrically a significantly greater bone-implant contact (BIC) rate after 6 months in the posterior human maxilla when a double–acid-etched surface was used rather than a machined surface (73% versus 34%).

In the present study, implants with an increased oxide layer (TiUnite) were compared with machined-surface implants by comparing the success rates of TiUnite and machined implants used to replace failed implants. The replacement implants were thus exposed to the same patient-related risk factors as the failed implants were.

MATERIALS AND METHODS

The files of 578 patients (326 female and 252 male), all treated during 3 consecutive years by means of oral implants at the Department of Periodontology, University Hospital Catholic University, Leuven, Belgium, were evaluated. The observation time ranged from 9 to 49 months. All patients had been provided with Brånemark System implants (Nobel Biocare). Within this group 2 implant surfaces were used: a machined surface and a surface modified by increased oxidation (TiUnite).

The geometry of the machined implants was either standard (Mk I), Mk II, or Mk III. In the Brånemark System, standard implants are used after pretapping the drilled alveolus, while Mk II and III are self-tapping screw-shaped implants. All are made of commercially pure titanium. The distribution of the implant types with their surface characteristics can be found in Table 1. For each patient the treatment history in the files was carefully analyzed. In cases where questions remained, the treating staff member was asked for further information. At implant placement, a minimal bone height of 7 mm was required. The same surgical protocol, with strict sterility measures, was used in all surgeries, including the replacement surgeries. A thorough departmental sterility policy allows the use of antibiotics to be limited to well-defined indications, eg, endocarditis prophylaxis, remaining infection at the site of surgery, or coughing or sneezing by the patient during surgery.

Data collection and analysis focused solely on implants that replaced nonosseointegrated implants, ie, failed implants. The failure rate of the original implants was calculated, and concomitant health or behavioral factors of the patients involved. Smoking habits, osteoporosis, hypo- or hyperthyroid states, and intake of antidepressant or steroid medication were of particular interest.[22] Smoking patients were allocated to 2 categories: 1 to 10 cigarettes per day and > 10 cigarettes per day.

Data were statistically analyzed by means of the standard Statistica for Windows software version 5.1 (Statsoft, Tulsa, OK); a Fisher exact *P* test was used. The *P* value was set at .05 to detect a level of significance.

RESULTS

A total of 41 patients (18 female, 23 male), aged 24 to 84 years, experienced nonintegration and had to receive new implants to replace failed ones. Some patients needed to have more than 1 implant replaced. Implant replacement was carried out 4 to 6 months after implant removal.

Table 1 Distribution of the Replacement Implants and Frequencies of Failures

	No. of implants replaced	Type		Time implant observed before failure (mo)		No. of replacement implants that failed	Time of failure of replacement implants (mo postplacement)
		Failed implant	New implant	Mean	Range		
Replaced by machined-surface implants (n = 29)	3	Mk I	Mk I	8.5	5 to 12	2	5 12
	2	Mk II	Mk I	24	12 to 36	1	12
	1	Mk I	Mk II	32	–	–	NA
	2	Mk II	Mk II	30	12 to 49	1	12
	13	Mk III	Mk III	31	3 to 45	2	3 24
	4	Mk II	Mk III	34	26 to 39	–	NA
	4	Mk I	Mk III	36	31 to 42	–	NA
Replaced by TiUnite implants (n = 29)	5	Mk I	TiUnite	23	9 to 32	–	–
	4	Mk II	TiUnite	29	20 to 35	–	–
	10	Mk III	TiUnite	21	9 to 35	1	12
	10	TiUnite	TiUnite	14	9 to 19	–	–

The difference in failure rate between machined-surface replacement implants and TiUnite replacement implants was statistically significant ($P = .05$).

Table 2a Distribution of Replacement Implant Lengths vs Previous Implant Lengths and Incidence of Replacement Implant Failures

	Length of replacement implant vs previous implant		
	Equal	Greater than	Less than
No. of replacement implants	30	4	24
No. of replacement implants that failed	3	1	3

Table 2b Distribution of Replacement Implant Diameters vs Previous Implant Diameters and Incidence of Replacement Implant Failures

	Diameter of replacement implant vs previous implant		
	Equal	Greater than	Less than
No. of replacement implants	46	6	6
No. of replacement implants that failed	5	0	2

Table 2c Distribution of Replacement Implant Location and Incidence of Replacement Implant Failures

	Location			
	Maxilla		Mandible	
	Anterior	Posterior	Anterior	Posterior
No. of replacement implants	16	22	8	12
No. of replacement implants that failed	2	3	0	2

Twenty-nine implants with a machined surface were replaced by machined-surface implants. Of the 29 replacement implants, 6 failed (5 within 1 year and 1 after 2 years of function).

Nineteen implants with a machined surface were replaced by implants with a TiUnite surface. Of the 19 replacement implants, 1 implant failed. Ten implants with a TiUnite surface were replaced by implants with the same surface. None of these have failed.

The distribution of implant lengths, diameters, and locations in the replacement group and the frequency of implant failure are shown in Tables 2a to 2c. The failure rate of the machined-surface replacement implants was significantly higher compared with that of the TiUnite replacement implants ($P = .05$) (Table 1).

Out of 326 female patients, 32 (9.8%) were smokers. Twenty smoked more than 10 cigarettes per day. Among the 252 male patients, 51 (20.2%) were smokers. Forty-three smoked more than 10 cigarettes per day.

In the replacement group, 2 of 18 female patients were smokers (1 more than 10 cigarettes per day), and 10 of 23 male patients were smokers (all more than 10 cigarettes per day) (Table 3).

Twenty-nine of 578 patients were known to have osteoporosis, compared to 2 of 41 patients in the replacement group. The numbers are too small to indicate a tendency toward higher incidence of osteoporosis in the replacement group. The respective frequencies of other relevant diseases can be found in Table 4.

Table 3 Distribution of Smokers and Nonsmokers in the Study Population and in the Replacement Group

	Study population (n = 578)	Replacement group (n = 41)
Nonsmokers		
Female	294	16
Male	201	13
Total	495	29
Smokers		
Female		
≤ 10/d	12	1
> 10/d	20	1
Total	32	2
Male		
≤ 10/d		0
> 10/d		10
Total		10

Two of 18 female patients in need of replacement implants were smokers; 10 of 23 male patients in need of replacement implants were smokers.

Table 4 Distribution of Some Systemic Diseases in the Total Patient Population and in the Replacement Group

	Study population (n = 578)		Replacement group (n = 41)	
	Female	Male	Female	Male
Total	326	252	18	23
Osteoporosis	24	5	2	–
Hyperthyroid	8	2	2	–
Hypothyroid	16	5	3	1
Medication				
Antidepressants	17	16	2	3
Steroids	5	1	1	–

Of the 58 implants in the replacement group, 33 were placed in patients who did not receive antibiotics at the replacement surgery. Four of these implants failed. The remaining 25 implants were placed in patients who received antibiotics immediately prior to and 1 or more days after surgery. Three of these implants failed.

DISCUSSION

The experimental hypothesis appeared to be confirmed: When failures of machined-surface implants occurred, replacement at the same site by a TiUnite implant with similar geometry led to an higher success rate. This was not the case when a failed implant was replaced by another machined-surface implant. Randomization was not applied in the present study; the replacement of a failed implant by either a TiUnite or a machined-surface implant was a forced choice. Indeed, the TiUnite surface was only used in the department for a certain period, which fell in the middle of the 3-year period studied. Thus, any bias could be excluded.

An implant newly placed at a site where an implant previously failed is again subjected to the same systemic and local compromising factors. Thus a comparison between the 2 groups leads to the identification of more or less the only significant variable, namely the implant surface. The other uncontrolled variable is that, at replacement, one is confronted with a nonpristine bone site, where latent inflammation or scar tissue from the previous surgical intervention may remain. This probably explains the higher failure rate for machined-surface implants replacing failed ones.

It has been reported that Brånemark System implants with a TiUnite surface experience faster bone apposition, which allows them to achieve a proper fixation even if a remaining endosseous lesion tends to compromise the osseointegration process.[23] While this would lead to early loss (ie, before or at abutment surgery) of the implant with a machined surface, with a TiUnite implant integration is already achieved in the coronal parts before the apical inflammatory process can compromise the ongoing bone apposition. This difference in bone apposition may be very relevant for replacing implants.

The impact of smoking habits on the outcome of osseointegration is again evidenced in the present study, as the number of smokers in the replacement group is high compared with the number of smokers in the total patient population. This is in agreement with previous studies.[24] The other systemic factors or medications,[22] although known to play an important role, could not be properly analyzed since the frequencies were too small.

Often, so-called sterile surgery is not in fact sterile; although sterile drapes and gowns may be used, the chain of sterility is often breached by lack of proper surgical training.

The small incidence of failures which is characteristic for the presently used implant system renders statistical analyses of success rates difficult. Nevertheless, the present analysis of the fate of implants placed at the same site where an implant recently failed allowed the improved surface to be assessed as having higher predictability.

CONCLUSION

An improved implant surface such as TiUnite may offer a better prognosis when a failed implant has to be replaced.

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