One-Year Clinical and Radiographic Results with a Novel Hydrophilic Titanium Dental Implant

Werner Degasperi, MD, DDS;[*,†] Peter Andersson, DDS;[*,†] Damiano Verrocchi, DDS;[†] Lars Sennerby, DDS, PhD[*,‡]

ABSTRACT

Background: New implant designs are continuously introduced to the market. It is important to evaluate and report on their clinical performance when used in everyday practice.

Purpose: The aim of the present study was to evaluate the clinical performance of a novel hydrophilic dental implant for 1 year.

Materials and Methods: A total of 49 patients previously treated with 102 hydrophilic dental implants (Neoss Proactive, Neoss Ltd, Harrogate, UK) were retrospectively evaluated with regard to survival rate and marginal bone loss. Fifty-four implants were installed in maxillae and 48 in mandibles to replace single teeth ($n = 21$), to support partial bridges ($n = 26$), total maxillary bridges ($n = 2$), or mandibular overdentures ($n = 2$). The majority of patients ($n = 37$) had implants placed in healed sites without any adjunctive procedures. In 12 patients, implants were immediately placed in extraction sockets or in conjunction with maxillary sinus floor augmentation. All implant sites had been classified according to the Lekholm and Zarb index. Baseline and 1-year intraoral radiographs were used to calculate marginal bone levels and bone loss. Implant stability quotient (ISQ) measurements had been taken at placement and after 3 to 4 months of healing

Results: The implants became rapidly covered with blood at the first contact. One implant was lost, giving a cumulative survival rate (CSR) of 99.0% after 1 year. The marginal bone loss amounted to 0.7 ± 0.6 mm with 3.5% of the implants showing more than 2 mm of bone loss and no implant more than 3 mm bone loss after 1 year. The primary stability was found to be 72.7 ± 7.5 ISQ, which slightly increased to 73.6 ± 7.2 ISQ (NS) after 3 to 4 months of healing. The stability was significantly higher in the mandible than in the maxilla at placement and after healing.

Conclusion: In this limited clinical study, the use of a novel hydrophilic dental implant results in favorable short-term outcomes.

KEY WORDS: clinical follow-up study, hydrophilic surface, implant survival, ISQ, marginal bone loss

INTRODUCTION

Dental implants are used in daily clinical routine to replace missing teeth. Good clinical outcomes with high implant survival rates and minimal marginal bone loss can be expected on most indications, although complications occur.[1–3] Primary stability is considered as one determinant of clinical success since high failure rates have been experienced in soft bone densities.[4,5] High failure rates have also been reported to occur in small bone volumes and in bone grafting situations.[1] However, most of the literature is based on the early experiences using the first generation of osseointegrated implants. Better understanding of the importance of clinical techniques and development of new implants designs and surfaces has resulted in improved surgical and prosthetic components. Based on studies on modern implant systems, it seems like the clinical results in soft bone, small bone volumes, and bone grafting situations are better than with the old implant techniques.[3,5,6] Furthermore, studies on immediate/early loading of implants have in general shown similar good results as when using two-stage procedures.[7] One

*Dentist, private practice, Clinica Feltre, Feltre, Italy; †Dentist, private practice, Fiera Di Primiero, Italy; ‡professor, Department of Oral & Maxillofacial Surgery, Institute of Odontology, University of Gothenburg, Gothenburg, Sweden

Reprint requests: Dr. Werner Degasperi, Clinica Feltre, Viale 18 Agosto 1866, 32032 Feltre (BL), Italy; e-mail: w_degasperi@hotmail.com

DOI 10.1111/cid.12022

important factor behind the good outcomes is probably the use of enhanced implant surfaces. Experimental research has shown that a slight increase of surface roughness results in a stronger bone tissue response compared with both smoother and rougher implant surfaces.[8] Moreover, increased hydrophilicity has been suggested and evaluated as one way to further improve the biocompatibility of implant surfaces.[9]

The Neoss implant system was introduced in 2003. It has a slightly tapered design, which results in firm primary stability due to continuous lateral clamping of the bone during insertion.[10] The original surface (Bimodal™, Neoss Ltd, Harrogate, UK) has a micro-texture due to double blasting with two different sizes of grits, which has been shown to improve implant integration and stability compared with smooth control implants.[11] Clinical follow-up studies have shown favorable clinical outcomes and minimal marginal bone loss after up to 5 years of function.[12–17] However, in spite of the blasting, the Neoss surface exhibits surface roughness on the lower part of the scale,[11] which may be disadvantageous for integration in challenging clinical situations. For instance, a lower survival rate was found in guided bone regeneration (GBR) treated sites compared with healed sites.[13] A novel surface (Proactive™, Neoss Ltd) has been developed by the Neoss company, exhibiting increased roughness and hydrophilic properties using electrowetting technology. Experimental research has demonstrated higher stability for the novel compared with the old surface.[18] A recent clinical study comparing Bimodal and Proactive Neoss implants showed higher survival rate for the latter after 6 months to 1 year of loading, with a marked difference in GBR sites.[19]

The aim of the present retrospective clinical study was to report on the experiences from the first 102 Neoss Proactive implants used by the present authors.

MATERIALS AND METHODS

Patients

The present retrospective study included the first >100 Neoss Proactive implants (Neoss Ltd) placed in 49 patients (29 female, 20 male, mean age 50.9 years, range 29 to 79 years). The inclusion criterion was implant treatment for replacing one or several teeth using a one- or two-stage technique and followed for at least 1 year in function. Immediate/early loading cases were not included. The presurgical radiographic examination included intraoral radiographs, orthopantomograms, and occasionally cone beam computerized tomography scans.

A treatment plan based on clinical and radiographic findings and discussions had been presented to the patients orally and in written. The patients were informed about clinical procedures, risks, complications, and expected outcome. All patients had been given their written consent to the therapy plan and follow-up procedures prior to treatment. All treatment steps were part of the routine procedures at the clinic and no extra measures were taken for the cause of the study. The study followed the directives given by the local Ethical Committee at the Feltre Hospital, Feltre, Italy, and in accordance with the World Medical Association Declaration of Helsinki.

Implants and Bone Conditions

Proactive implant surface (Neoss Proactive) is produced by blasting with titanium particles followed by acid etching (Figure 1). The surface is then chemically modified to reduce surface tensions and to exhibit electro-wetting in contact with fluids. According to the manufacturer, the surface roughness (S_a value) is about 1.0 μm on the implant body and 0.4 μm on the collar, which is only acid etched.

A total of 102 dental implants in diameters from 3.5 mm to 5 mm and in lengths from 7 mm to 15 mm had been placed (Table 1). Fifty-four implants were

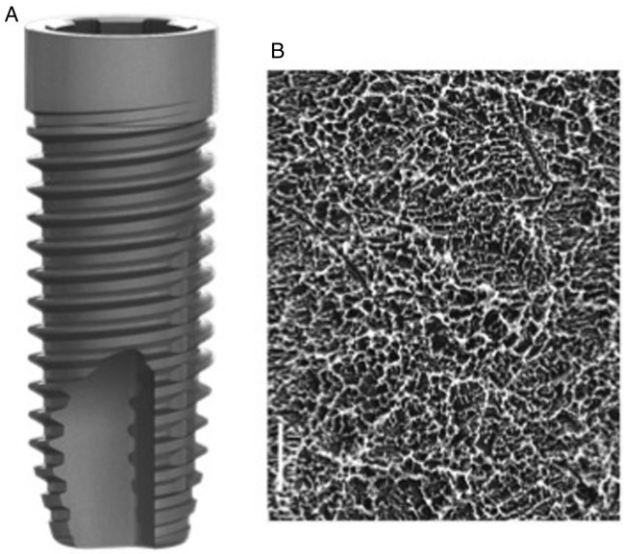

Figure 1 *A*, Showing the Neoss Proactive implant design. *B*, SEM picture of the blasted, acid-etched and chemically modified implant surface. Bar = 10 μm.

TABLE 1 Implant Diameters and Lengths Used in the Study

Implant Diameter	Implant Length					Total
	7 mm	9 mm	11 mm	13 mm	15 mm	
3.5 mm		1	1*	1		3
4.0 mm		14	29	23	7	73
4.5 mm	1	4	6	2		13
5.0 mm		7	6			13
Total	1	21	42	25	7	102

*Failed.

installed in maxillae and 48 in mandibles to replace single teeth (12 lower, 9 upper), to support partial bridges (12 lower, 14 upper)), total maxillary bridges ($n = 2$) or mandibular overdentures ($n = 2$) (Table 2). All implant sites had been classified according to the Lekholm and Zarb index[20] (Table 3).

Clinical Procedures

Patients were given 2 g amoxicillin (Augmentin™, GlaxoSmithCline, Verona, Italy) prior to implant surgery. If required, the patients were also given diazepam (0.15 mg/kgBw). Surgery was made under sterile conditions in local anesthesia with articaine (4%) with epinephrine (1/100,000) (Septanest™, Septodont, Saint-Maur-des-fossés, France). The bone was exposed via a mid-crest incision. The majority of patients ($n = 37$) had implants placed in healed sites without any adjunctive procedures. In nine patients, 11 implants were immediately placed in extraction sockets with (five patients/five implants) or without (four patients/six implants) simultaneous placement of bone substitute (Genoss, Osteo-Biol, Turino, Italy). Three patients underwent maxillary sinus floor augmentation and simultaneous implant placement (seven implants) using bone substitutes (two patients) or sinus membrane elevation only (one patient).

TABLE 2 Type of Prosthesis and Jaw

	Mandible	Maxilla
Single tooth replacement	12	9
Fixed partial prosthesis	12	14
Fixed total prosthesis	2	—
Overdenture	—	2

Implant site preparation was made using a 2.2-mm spiral drill for the possibility of making screw-retained crowns and bridges. A 3.0-mm drill was then used which was the final diameter for 3.5-mm wide implants. When using 4-mm wide implants, a 3.4-mm drill was used and a 3.9-mm drill for 4.5-mm wide implants and a 4.6-mm drill for 5 mm wide implants. In case of soft bone, the final drill diameter was reduced one step to improve primary stability. A countersink drill was used and the implants placed flush with the bone crest. The implants were inserted with a preset insertion torque of 40 Ncm. The final insertion was made using a manual wrench. Implant stability was measured with resonance frequency analysis (RFA, Osstell Mentor™, Osstell AB, Gothenburg, Sweden) in implant stability quotient values (ISQ). Cover screws ($n = 93$) or healing abutments ($n = 9$) were applied and the wound closed. In two-stage cases abutment connection was made 3–4 months after implant placement using a punching technique or flap procedure. RFA measurements were performed at abutment connection or when the prosthetic treatment commenced.

TABLE 3 Bone Quality and Quantity according to the Lekholm and Zarb Index

Bone Quantity	Bone Quality				Total
	1	2	3	4	
A					—
B	2	13	20	4	39
C		36	15	4	55
D	2	2	3		7
E			1		1
Total	4	51	39	8	102

Impressions were made at fixture level using Impregum (ESPE, Seefeld, Germany) and an open tray. The prostheses were made on Neolink™ abutments (Neoss Ltd) made of titanium or gold depending on the material of the framework. Both porcelain and acrylic teeth were used in the study. All fixed prostheses were screw-retained and the access holes covered with composite fillings. Overdentures were retained to two implants using a straight bar and clips in the mandible. Occlusion was controlled aiming for group function and avoiding loading of cantilever teeth. Function and occlusion was further checked 2–4 weeks after delivery of the prosthetic appliance.

Follow-Up Measurements

All patients were followed for 1 year of loading. Intraoral radiographs were taken at impression and after 1 year for measurements of marginal bone loss. The upper corner of the coronal shoulder of the implant was used as reference point, and measurements from the reference point to the first bone contact at the mesial and distal aspects of the implant were performed using a PC and specially designed software (Image-J, National Institutes of Health, Bethesda, MD, USA) (Figure 2). A mean value was calculated for each implant and time point.

An implant was considered a survival if clinically stable and complying with the function of supporting the prosthesis and causing no discomfort to the patient. Failure was defined as removal of an implant because of any reason.

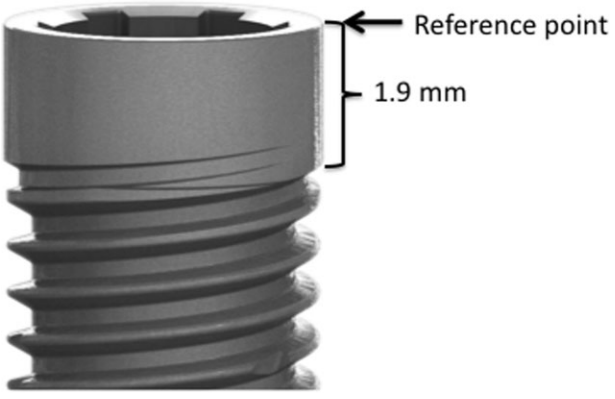

Figure 2 Schematic showing the reference point used for measurements of crestal bone levels and bone loss in radiographs. The collar is 1.9 mm high.

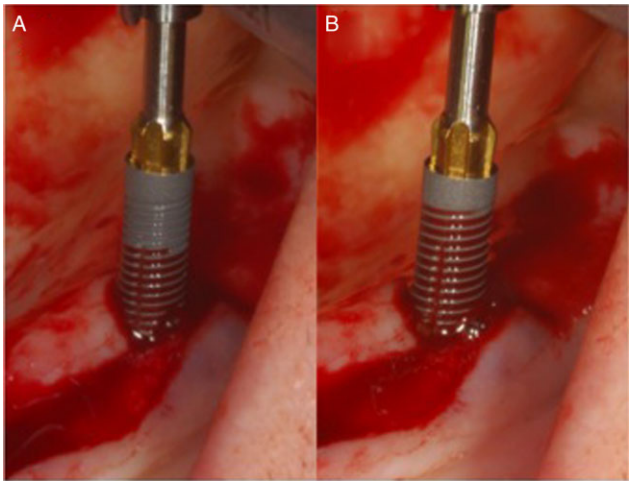

Figure 3 Clinical photos demonstrating electro-wetting. (A) The implant has just been in contact with blood from the osteotomy. (B) A few seconds later. The implant threads are totally soaked with blood.

Statistics

Student's *t*-test and Spearman's correlation tests were used for statistical analyses of marginal bone and RFA data. A significant difference or correlation was considered when $p < .05$.

RESULTS

Clinical Findings

The implants showed hydrophilic properties and blood soaked the whole implant surface at the first contact (Figure 3).

Apart from expected postoperative discomfort, no adverse events were noted during the healing period. All implants were stable after healing and connected to prosthetic constructions.

One implant was lost during clinical function, giving an implant survival rate of 99% after 1 year of function. In spite of the single implant failure, all prosthetic constructions maintained in function.

The lost implant (3.5 mm/11 mm) had been placed in an extraction socket in the mandible and simultaneously augmented with bone substitute (Figure 4). Although stable at abutment connection, discomfort and pain developed after 3 months of clinical function. The bridge, supported by three implants, was removed and the implant found to be mobile and was removed. The bridge was reconnected to the two stable implants. A new implant was inserted 2 months later and allowed

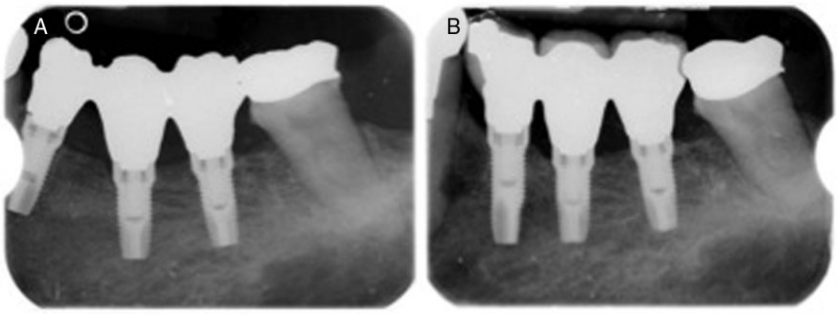

Figure 4 Intraoral radiographs of a patient with a failed implant. (A) The mesial implant (left) had been placed in an extraction socket with a bone substitute. The implant was removed after 3 months of function due to discomfort and mobility. (B) A new implant was placed and connected to the bridge.

to heal for 3 months, when the implant was exposed and included in the bridge.

Implant Stability Measurements

The primary stability ($n = 102$) was found to be 72.7 ± 7.5 ISQ, which slightly increased (NS) to 73.6 ± 7.2 after 3 to 4 months of healing ($n = 98$) (Table 4). The stability was significantly higher in the mandible than in the maxilla at placement (76.8 ± 6.5 ISQ vs 69.2 ± 6.7 ISQ, $p < .001$) and after healing (77.1 ± 6.7 ISQ vs 70.7 ± 6.3 ISQ, $p < .001$) (Table 4). There was a significant inverse correlation between bone density (Lekholm and Zarb index) and primary stability ($p < .001$). There was a significant inverse correlation between primary stability and change of stability ($p < .001$) (Figure 5).

The failed implant showed a stability of 74 ISQ at placement, which dropped to 64 ISQ at abutment connection.

Radiographic Findings

The marginal bone level was situated 0.3 ± 0.5 mm ($n = 102$) below the reference point after 3 to 4 months of healing and 0.9 ± 0.7 mm ($n = 86$) after 1 year in function (Table 5). The marginal bone loss as calculated in paired baseline and 1-year radiographs was 0.5 ± 0.6 mm after 1 year, based on 86 pairs of baseline and 1-year radiographs (Table 5; Figure 6).

Frequency distribution of marginal bone loss showed that 3.5% of the implants had more than 2 mm of bone loss. No implant showed more than 3 mm bone loss after 1 year (Table 5).

TABLE 4 Results from Osstell Measurements

	Placement (ISQ ± SD)	After Healing (ISQ ± SD)	Statistics
All implants	72.7 ± 7.5	73.6 ± 7.2	NS
Mandible	76.8 ± 6.5	77.1 ± 6.7	NS
Maxilla	69.2 ± 6.7	70.7 ± 6.3	NS, $p < .001$*

*Mandible versus maxilla at placement and after healing.

DISCUSSION

The aim of the present study was to evaluate the clinical performance of a novel hydrophilic surface exhibiting electro-wetting in contact with blood. For this purpose, it was decided to retrospectively evaluate the first 100 implants used by the present authors. Most patients were treated for single-tooth replacements and short span fixed partial bridges involving two or three

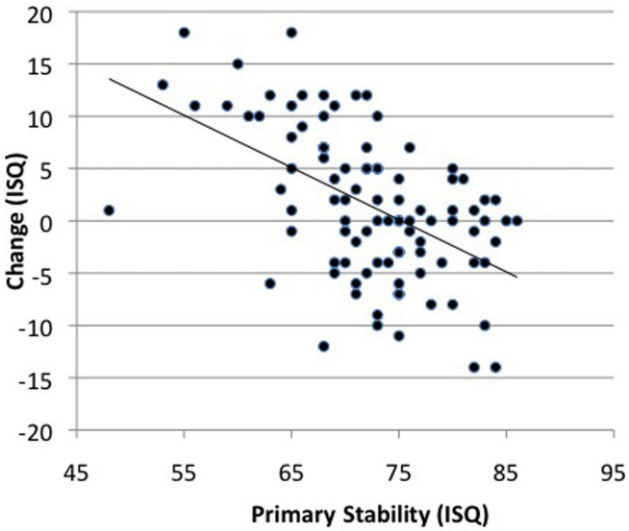

Figure 5 Graph showing a significant ($p < .001$) inverse relation between primary stability and change of stability after 3 to 4 months of healing.

TABLE 5 Results from Radiographic Measurements

	Baseline mm ± SD	One-Year mm ± SD
Bone level	0.3 ± 0.4 (n = 102)	0.9 ± 0.7 (n = 86)
Bone loss		0.7 ± 0.6 (n = 86)
Frequency of bone loss		(%)
<0.0 mm		10.5
0–1.0 mm		60.5
1.1–2.0 mm		25.5
2.1–3.0 mm		3.5
>3.0		0

implants. Few total jaws were included in the present study. The main reason is that these are treated using an early loading protocol in our clinic and immediate/early loading was an exclusion criterion for the present study. The outcome of these will be presented in a separate study. The use of short implants has historically been regarded as a risk factor for implant failure.[5] However, this was not observed in the present study. Since mainly premolar and molars were replaced, the majority of implants were 7 to 11 mm in length (64 of 102) and only one 11-mm implant was lost. Similar results were found in a previous study on the same implant design but a different surface.[12]

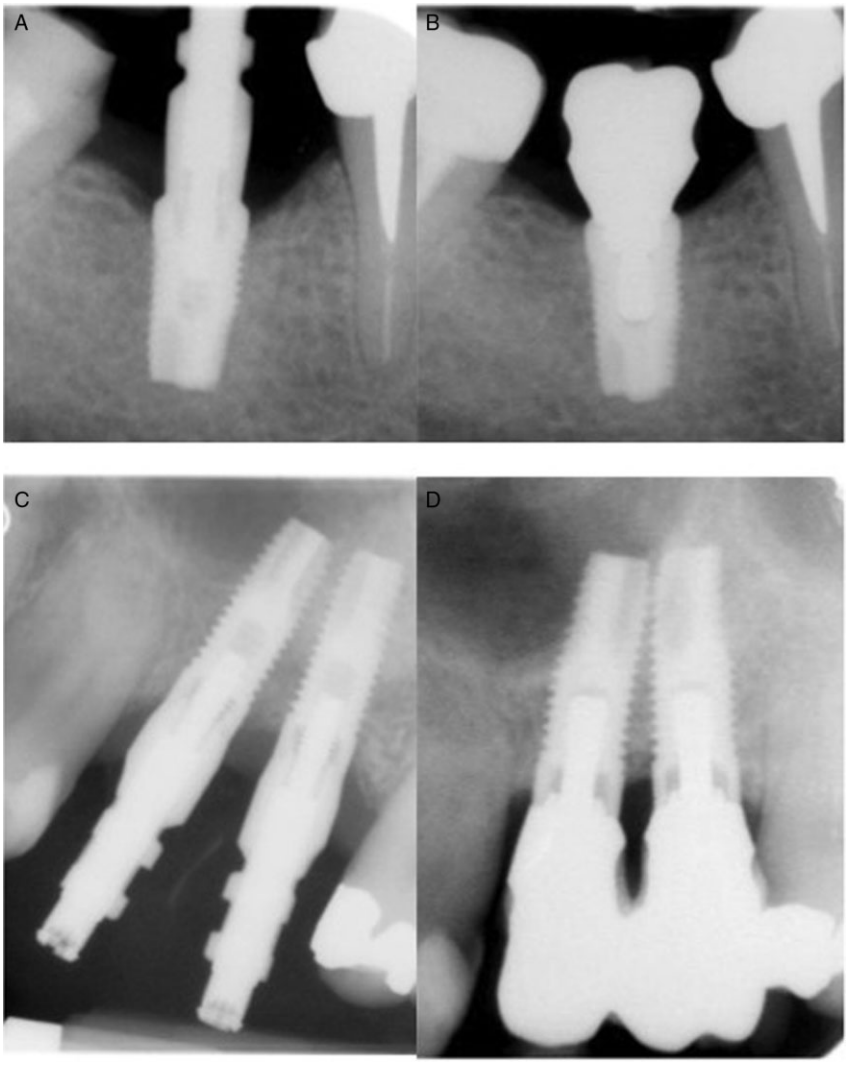

Figure 6 Radiographic examples of clinical cases. (A) 5/11 mm implant at baseline for replacement of mandibular first molar; (B) one-year check-up radiograph; (C) two 4/13 mm implants at baseline placed together with a sinus lift procedure; (D) one-year check-up radiographs.

The implants had been used in consecutive cases for replacement of one or several missing teeth in both jaws using a two- or one-stage procedure with 3 to 4 months of healing prior to loading. The majority of implants were placed in healed sites although about 25% of the patients had implants placed in extraction sockets or in conjunction with a sinus lift procedure. Only one of 102 implants failed after 1 year of function, giving a CSR of 99.0%. The failed implant was a narrow implant (3.5 mm in diameter) placed in an extraction socket together with a bone substitute. Previous studies on the Neoss implant with the Bimodal surface have shown survival rates from 93.0% to 98.6% after 1 to 5 years of loading.[12–17] Thus, the present study showed a higher survival rate compared with the previous ones. This research group found a survival rate of 98.6% for Bimodal implants after 1 year,[12] which suggests negligible differences compared with the present study. However, more challenging cases were treated in this study and, in fact, no Proactive implants placed in healed sites failed.

The average marginal bone loss in the present study was 0.7 mm after 1 year in function, which is in line with the previous studies on Neoss Bimodal implants.[12–17] The marginal bone loss was also similar compared with other modern implant systems,[3] which indicates favorable bone tissue reactions to the tested implant design. No cases with peri-implant infection were seen in the present study. One reason for the favorable results may be the fact that the collar of the implant has a relatively smooth surface compared with the body. However, although anticipated that surface roughness is a risk factor, the influence on marginal bone loss is not well understood. For instance, similar average bone loss and incidence of marked bone resorption have been reported to occur around smooth and oxidized Brånemark implants.[21]

The first generation of osseointegrated implants had either a minimally rough surface from the turning process or a marked roughness due to plasma-spraying with titanium or hydroxyapatite. The second generation of implants, which still are in use, were commonly provided with a moderately rough surface by using grit-blasting, acid etching, anodic oxidation, or a combination of techniques.[22] Experimental studies have shown a stronger bone tissue response to moderately rough surfaces than to both smoother and rougher control surfaces.[8,22] This is seen as a direct formation of more bone to the surface at an early stage by the so-called contact osteogenesis in contrast to distance osteogenesis observed at smooth implant surfaces.[23] One explanation for contact osteogenesis at enhanced implant surfaces is that the initial blood clot is better retained at rough surfaces.[24] Mesenchymal cells can migrate through the clot to the implant surface, differentiate into osteoblasts and start to lay down collagen matrix for mineralization direct on the substrate.[23] Further improvements of implant surfaces have focused on using nanotechnology to improve cellular adhesion and chemical modification to increase the hydrophilicity of the implant.[25] The latter is considered beneficial due to an increased adhesion and retention of the blood clot, which may facilitate early population of osteopotent cells at the interface. In vitro studies comparing hydrophilic and non-hydrophilic surfaces have shown a similar or higher cell adhesion to the former surface.[9] However, most studies have shown an increased cellular activity and production of osteocalcin, osteoprotegerin, and growth factors, which may have an impact on angiogenesis and early bone formation.[9] Data from in vivo studies have demonstrated more bone-to-implant contacts at hydrophilic implant surfaces during the early healing period, which support the idea of an enhanced integration.[9] Comparative clinical studies have indicated some advantages with hydrophilic over hydrophobic surfaces but no significant differences with regard to survival rates.[9] For instance, a recent clinical report on the same hydrophilic surface as used in the present study demonstrated the absence of an initial decrease of implant stability as commonly seen for one-stage implants with hydrophobic surfaces.[26] However, controlled clinical studies using hydrophilic and hydrophobic implants with the same surface roughness are needed to prove possible positive effects of increased hydrophilicity. Moreover, even in well-controlled situations it is difficult to rule out the importance of one isolated parameter. For instance, the surface roughness seems to increase when chemically modifying an implant surface to be hydrophilic.[9] With regard to Neoss implants, apart from hydrophilic properties, there are differences in surface roughness when comparing Proactive and Bimodal surfaces, since the former has a higher roughness (S_a 1.0 μm) than the latter (S_a 0.6 μm). Thus, it is possible that the increased roughness alone can explain improved clinical performance.[19,26]

Osstell measurements revealed a firm primary stability which increased slightly over 3 to 4 months of healing, indicating a favorable tissue response during healing. It is believed that ISQ describes the stiffness of the bone-implant interface, which primary is determined by the bone density.[27] The surgical preparation of the osteotomy initiates a healing response, which results in bone formation and remodeling. Thus, an increased ISQ unit with time reflects an increased stiffness due to the healing process. An inverse correlation was seen between bone density and change of stability from baseline to 3 to 4 months of healing as also shown by other authors.[12,28] This means that implants placed in soft bone benefits more from the healing process than implants in dense bone in terms of increased stability. In fact, these studies showed no differences in stability between different bone densities after 1 year in function, which shows that all implants might reach a similar degree of stability although different healing times may be needed. Thus, extending healing time is one way of improving implant stability in soft bone.

It is concluded that the tested implant was rapidly covered by blood when placed in the osteotomy, thus exhibiting hydrophilic properties. Good clinical results were obtained with a CSR of 99.0% and 0.7 mm bone loss after 1 year of loading when using a two- or one-stage procedure with 3 to 4 months of healing.

REFERENCES

1. Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci 1998; 106:527–551.
2. Pjetursson BE, Tan K, Lang NP, Brägger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. Clin Oral Implants Res 2004; 15:625–642.
3. Laurell L, Lundgren D. Marginal bone level changes at dental implants after 5 years in function: a meta-analysis. Clin Implant Dent Relat Res 2011; 13:19–28.
4. Sennerby L, Roos J. Surgical determinants of clinical success of osseointegrated oral implants: a review of the literature. Int J Prosthodont 1998; 11:408–420.
5. Sun HL, Huang C, Wu YR, Shi B. Failure rates of short (≤10 mm) dental implants and factors influencing their failure: a systematic review. Int J Oral Maxillofac Implants 2011; 26:816–825.
6. Del Fabbro M, Rosano G, Taschieri S. Implant survival rates after maxillary sinus augmentation. Eur J Oral Sci 2008; 116:497–506.
7. Ostman PO. Immediate/early loading of dental implants. Clinical documentation and presentation of a treatment concept. Periodontol 2000 2008; 47:90–112.
8. Wennerberg A, Albrektsson T. Effects of titanium surface topography on bone integration: a systematic review. Clin Oral Implants Res 2009; 20(Suppl 4):172–184.
9. Wennerberg A, Galli S, Albrektsson T. Current knowledge about the hydrophilic and nanostructured SLActive surface. Clin Cosmet Investig Dent 2011; 3:59–67.
10. Pagliani L, Sennerby L, Anderson P, Verrocchi D, Meredith N. Insertion torque measurements during placement of Neoss implants. Appl Osseointegration Res 2008; 6:36–38.
11. Sennerby L, Gottlow J, Engman F, Meredith N. Histological and biomechanical aspects of surface topography and geometry of Neoss implants. A study in rabbits. Appl Osseointegration Res 2008; 6:8–22.
12. Sennerby L, Andersson P, Verrocchi D, Viinamäki R. One-year outcomes of Neoss bimodal implants. A prospective clinical, radiographic, and RFA study. Clin Implant Dent Relat Res 2012; 14:313–320.
13. Zumstein T, Billström C, Sennerby L. A 4- to 5-year retrospective clinical and radiographic study of Neoss implants placed with or without GBR procedures. Clin Implant Dent Relat Res 2012; 14:480–490.
14. Pagliani L, Andersson P, Lanza M, et al. A collagenated porcine bone substitute for augmentation at Neoss implant sites: a prospective 1-year multicenter case series study with histology. Clin Implant Dent Relat Res 2012; 14:746–758.
15. Dahlin C, Widmark G, Bergkvist G, Fürst B, Widbom T, Kashani H. One-year results of a clinical and radiological prospective multicenter study on NEOSS® dental implants. Clin Implant Dent Relat Res 2011. DOI: 10.1111/j.1708-8208.2011.00356.x
16. Volpe S, Lanza M, Verrocchi D, Sennerby L. Clinical outcomes of an osteotome technique and simultaneous placement of Neoss implants in the posterior maxilla. Clin Implant Dent Relat Res 2011. DOI: 10.1111/j.1708-8208.2011.00378.x
17. Becker W, Becker BE, Hujoel P, Abu Ras Z, Smidt A, Goldstein M. Prospective clinical trial evaluating a new implant system for implant survival, implant stability and radiographic bone changes. Clin Implant Dent Relat Res 2011. DOI: 10.1111/j.1708-8208.2010.00333.x
18. Gotttlow J, Sennerby L. An experimental comparison of Neoss implants with either a double blasted or a blasted and acid-etched hydrophilic surface. In manuscript.
19. Zumstein T, Divitini N, Meredith N. A comparative retrospecitve follow up of patients treated with implants either

with a blasted or super hydrophilic surface with or without an adjunctive GBR procedure. J Implant Adv Clin Dent 2011; 3:49–58.

20. 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, 1985:199–209.
21. Friberg B, Jemt T. Clinical experience of TiUnite implants: a 5-year cross-sectional, retrospective follow-up study. Clin Implant Dent Relat Res 2010; 12(Suppl 1):e95–103.
22. Albrektsson T, Wennerberg A. Oral implant surfaces: part 1 – review focusing on topographic and chemical properties of different surfaces and in vivo responses to them. Int J Prosthodont 2004; 17:536–543.
23. Davies JE. Understanding peri-implant endosseous healing. J Dent Educ 2003; 67:932–949.
24. Park JY, Davies JE. Red blood cell and platelet interactions with titanium implant surfaces. Clin Oral Implants Res 2000; 11:530–539.
25. Le Guéhennec L, Soueidan A, Layrolle P, Amouriq Y. Surface treatments of titanium dental implants for rapid osseointegration. Dent Mater 2007; 23:844–854.
26. Rosen P, Meredith N, Reynolds M. Case reports describing the "bump": a new phenomenon in implant healing. J Implant Adv Clin Dent 2010; 2:27–37.
27. Sennerby L, Meredith N. Implant stability measurements using resonance frequency analysis: biological and biomechanical aspects and clinical implications. Periodontol 2000 2008; 47:51–66.
28. Friberg B, Sennerby L, Meredith N, Lekholm U. A comparison between cutting torque and resonance frequency measurements of maxillary implants. A 20-month clinical study. Int J Oral Maxillofac Surg 1999; 28:297–303.