Oxidized Titanium Implants in Reconstructive Jaw Surgery

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ABSTRACT

Background: Rehabilitation with implant-supported bridges in patients with insufficient bone volumes may require bone reconstructive procedures in conjunction with or prior to implant placement. Clinical follow-up studies using turned titanium and bone grafts have demonstrated higher failure rates than when used in nongrafted patients. Improved bone integration has been demonstrated for oxidized titanium implants; however, their clinical performance in bone reconstruction situations is not known.

Purpose: This study was performed to analyze the survival and stability of oxidized titanium implants placed in patients subjected to reconstructive jaw surgery at one clinic.

Materials and Methods: Two hundred oxidized titanium implants (Mk III, TiUnite™, Nobel Biocare AB, Göteborg, Sweden) were placed in 47 patients in conjunction with or secondary to six different reconstructive procedures owing to insufficient bone volume. In all six groups, implant stability was assessed by resonance frequency analysis and manually checked for rotation stability at implant insertion, at the time of abutment connection, and after a minimum of 12 months of loading of the prosthetic construction. Periapical radiographs were taken after a minimum of 12 months of loading (mean 21 months) for evaluation of the marginal bone levels. The mean clinical follow-up period was 30 months.

Results: Of the 200 implants, 199 were considered osseointegrated at the time of abutment surgery. At the 12-month post-loading follow-up, another two implants were considered not stable. Three implants (1.5%) were ranked as unsuccessful.

Conclusion: Clinical experience with 200 consecutive oxidized implants in various reconstruction situations shows a successful outcome, with only three failures (1.5%) during a mean follow-up period of 30 months.

KEY WORDS: anodic oxidation, implants, jaw bone reconstruction, modified surface, resonance frequency analysis

Rehabilitation with implant-supported bridges in patients with insufficient bone volume may require bone reconstructive procedures in conjunction with or prior to implant placement. Different techniques can be used depending on the location and extent of bone loss and the intermaxillary relationship.[1] In the severely resorbed maxilla, sinus floor augmentation and onlay bone grafting are commonly used for reconstruction.[2–7]

Correction of intermaxillary relation can be achieved by advancing the maxilla using a Le Fort I procedure with interpositional bone grafts.[3,6] In the reconstructive procedures, autogenous bone from intra- or extraoral donor sites is regarded as the "gold standard," even though a secondary surgical site is necessary for the bone harvesting.[7] Moreover, procedures involving onlay bone grafts benefit from the use of a healing period for the graft before placing the endosteal implants.[8] Apart from bone grafting procedures, zygoma implants[9] and alveolar distraction osteogenesis are also used for reconstruction purposes.[10–12]

Bone reconstruction procedures involve complex situations with the risk of compromised healing situations. The healing of titanium implants in the grafted bone involves a challenging situation both when the implants are placed simultaneously with the graft or after the primary healing of the graft. Compromised general health owing to osteoporosis or endocrine disorders with a higher risk of complications and compromised bone graft density, as well as decreased healing capacity, in

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elderly patients are factors contributing to the challenging clinical situation in bone reconstructive procedures prior to or in conjunction with titanium implant treatment. Moreover, achieving and maintaining implant stability in the primary healing phase seem to be more difficult in the bone reconstructive situation. The failure rates of turned (machined) implants in grafted bone are higher than the failure rates in implants placed in nongrafted bone owing to the factors mentioned above.[1,13]

Experimental and preliminary clinical studies have demonstrated that implant surface modification can lead to more rapid integration and a higher degree of bone-implant contact compared with turned implants.[14–19] The clinical effect of oxidized titanium implants used in the reconstructed situation is not yet described in the literature. It can be expected to find fewer implant failures with the oxidized surface than with the turned surface owing to the achievement of a better stability in the primarily healing period and enhanced bone formation in the bone-implant contact.[16,17,19]

This study was initiated to analyze the first 200 consecutively placed oxidized titanium implants (TiUnite™, Nobel Biocare AB, Göteborg, Sweden) exclusively in patients subjected to reconstructive jaw surgery at the Department of Oral and Maxillofacial Surgery, Umeå University, Sweden.

MATERIAL AND METHODS

Patients

The study included 47 patients, 26 female and 21 male, with an average age of 53 years (range 17–77 years).

Two hundred oxidized titanium implants (Mk III, TiUnite) were placed in conjunction with or secondary to six different reconstructive procedures (Table 1 and Figure 1, A–C).

Surgical Procedures

Group 1. The sinus elevation technique included preparation of a replaceable bone window, careful elevation of the sinus mucosa, and simultaneous placement of implants in the residual bone. The implants were protruding into the sinus cavity at least 5 mm, and then the bone window was replaced. No graft material was used.[20] Nine patients had 19 implants between 10 and 15 mm inserted in the residual bone of the maxillary sinus floor. The vertical height of the residual bone was, on average, 7 mm. The implants protruded into the sinus cavity between 5 and 8 mm.

Group 2. Sinus inlay grafting and local onlay grafting were performed in two stages with the harvested bone taken from the mandibular ramus, and the bone graft was allowed to heal for 6 months prior to implant placement.[21,22] Fourteen patients had 32 implants placed in the inlay or onlay grafts.

Group 3. Maxillary reconstruction of the atrophic edentulous maxillae was performed with onlay bone grafts harvested from the anterior iliac crest.[7] The reconstructive surgery was performed in general anesthesia 6 months prior to implant placement. Thirteen patients had 99 implants placed in this group .

Group 4. Interpositional bone grafting combined with a Le Fort I osteotomy was carried out in two patients with atrophic edentulous maxillae, where an intermaxillary correction was necessary in addition to bone reconstruction. The surgery was performed in general anesthesia, and the bone graft was harvested from the anterior iliac crest.[6] Graft healing time was 6 months, and 15 implants were inserted in the two patients.

Group 5. Reconstruction with zygomaticus implants and anterior regular implants was performed in three patients. Surgery was performed in general anesthesia, and each patient had two zygomaticus implants placed bilaterally. Two patients had four and one patient had three anterior regular implants (TiUnite) placed simultaneously.

Group 6. Vertical distraction osteogenesis was performed in six patients (see Figure 1, A–C). Two patients with atrophic edentulous maxillae were first subjected to maxillary reconstruction with onlay grafting from the iliac crest, preformed in general anesthesia. After 6 months of graft healing, the patients were subjected to a second reconstructive surgery in local anesthesia and conscious sedation when a totally alveolar osteotomy within the healed graft was performed. Two distraction devices (Track 1.5, Martin Med.Technik, Tuttlingen, Germany) were used for vertical distraction osteogenesis. In four patients, vertical distraction was performed to correct local defects in the maxilla and the mandible.

After implant insertion, 188 of the 200 implants were submerged during healing, whereas 12 were left nonsubmerged with a healing abutment until connection of final abutments. Time to abutment surgery was,

TABLE 1 Number of Placed and Failed Oxidized Implants for Different Reconstructive Procedures

	Sinus Elevation	Sinus Grafting and Local Onlay Graft	Maxillary Onlay Graft	Maxillary Interpositional Graft (Le Fort I)	Anterior Implants with Zygomatic Implants	Vertical Distraction	Total
Placed implants	19	32	99	15	11	24	200
Loaded implants	19	32	99	15	11	24	200
Failure	1	1	—	1	—	—	3
Follow-up, mean (mo)	35.3	25.9	27.6	34.2	27.3	27.1	

on average, 5.7 months, with a range from 3.5 to 9.4 months (see Table 1).

Follow-Up

Implant stability was assessed manually using a screwdriver and by resonance frequency analysis (RFA) (Osstell™, Integration Diagnostics AB, Sävedalen, Sweden) at implant insertion, at the time of abutment connection, and after a minimum of 12 months (mean 30 months, range 12–48 months) of loading of the prosthetic construction. The third RFA measurement required removal of all screw-retained constructions, which was made after 12 months or more of loading (mean 24 months, range 12–38 months). The prosthetic constructions could be removed in 32 of the 47 patients. Thirteen patients had cemented crowns, and two patients dropped out owing to severe health problems.

Periapical radiographs were taken after a minimum of 12 months of loading (mean 21 months, range 12–33 months) in 44 of the 47 patients for evaluation of the marginal bone levels. The distance from the implant/abutment junction to the most coronal point of the marginal alveolar bone adjacent to the implant was measured on both sides of the implant with a loupe, and the mean values were used in the calculations. Three patients had no radiographs taken; two patients had moved out of the region and refused to participate in the follow-up. One patient had severe health problems.

RESULTS

Of the 200 implants, 199 were considered as integrated at the time of abutment surgery. One implant, 10 mm in length, placed in a patient reconstructed with an interpositional bone graft and a Le Fort I osteotomy was considered nonintegrated and was removed.

All remaining implants were functionally loaded with prosthetic constructions. At the final postloading follow-up, another two implants were considered rotational mobile: (1) one 10 mm–long implant placed in a maxillary sinus grafted with bone from the mandibular ramus; this implant showed decreasing implant stability quotient (ISQ) values from 67 to 53; (2) one 10 mm–long implant placed with a sinus elevation procedure without grafting; this implant showed stable ISQ values, from 64 to 63. Thus, three (1.5%) implants were ranked as unsuccessful.

RFA measurements of all implants showed no changes in stability from placement to abutment con-

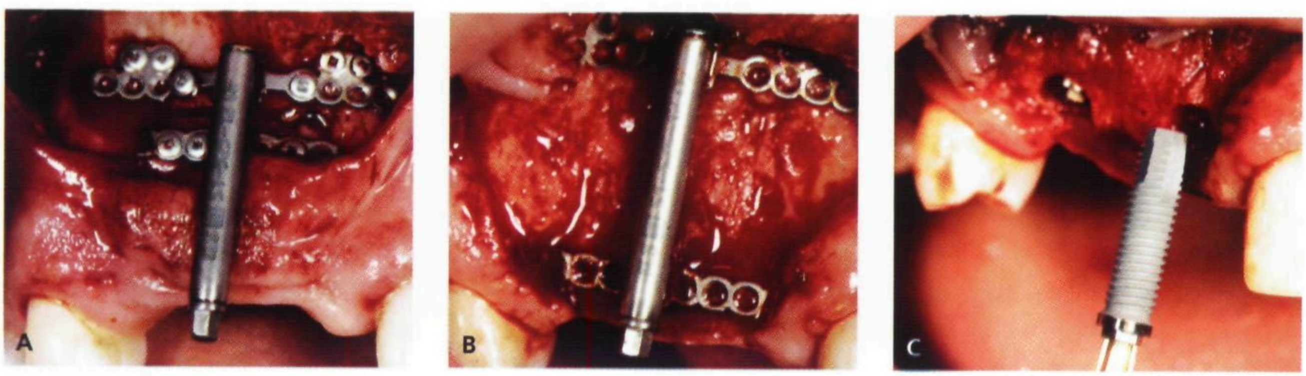

Figure 1 Showing the first case in which oxidized implants were used. Vertical osteodistraction is performed in a partially edentulous maxilla with traumatic loss of teeth and bone. *A,* Distraction device in position. The marginal bone segment has been separated from the crest. *B,* After completed distraction and consolidation, about 3 months later. *C,* TiUnite implants are placed.

nection, ISQ 58.2 (SD 7.3) and 58.6 (SD 6.7), respectively. There was a statistically significant increase to the third registration, 63.2 (SD 5.9).

The marginal bone level was, on average, 2.2 mm (SD 0.5 mm) from the implant/abutment junction after a minimum of 12 months of loading.

DISCUSSION

In the present study, 200 titanium implants with an oxidized surface were placed in 47 patients subjected to reconstructive bone surgery. All implants were individually checked with RFA and/or manual tests at implant placement and abutment connection surgery and the majority of implants after a minimum of 12 months of loading. Only three failures (1.5%) were encountered, and all patients received and maintained the planned fixed prosthetic constructions during the observation period for this study (mean 30 months follow-up). Considering the complex healing situations represented by the different reconstructive techniques, the present results are most encouraging. Moreover, the same team has recently reported an 8% failure rate after 1 year of function of turned titanium implants in grafted maxillae,[23] indicating a more favorable outcome with oxidized implants when used in bone reconstruction situations. However, comparative clinical studies are needed to statistically verify this.

In the present retrospective material, a mixture of orthopantomograms and periapical radiographs was available from after abutment connection and delivery of the prosthetic constructions. However, the follow-up radiographs could be taken with a standardized technique, and only these were used to assess the level of the marginal bone. The marginal bone was located, on average, 2.2 mm from the implant/abutment junction, which was used as a reference point. Estimation suggests a bone loss of about 1.6 mm during the follow-up because the implant heads (0.8 mm high) were not submerged at placement. Considering that the mean time from placement to radiography was 21 months, our result is comparable to what has been previously reported.[13]

RFA of successful implants showed an increase in ISQ levels from placement to the registration made after 12 months or more of loading for all except the sinus elevation patients. An initial drop in the ISQ values from the insertion of implants to abutment surgery, as observed in this study, was also reported by Sjöström and colleagues.[23] This is likely explained by the use of a reduced final drill diameter during placement of the implants. A similar effect can be achieved with tapered implant designs, as also demonstrated in vitro.[24]

Three implant failures were observed in three different reconstructive procedures. One 10 mm implant in a maxillary interpositional bone graft was not integrated at the abutment surgery. It was not rotation stable at placement, indicating a low primary stability. A correlation between low initial stability and failure was demonstrated for turned titanium implants in the grafted maxilla.[23] Two implants were judged as failed at the follow-up checkup when bridges were removed. None of the two patients complained of any symptoms prior to the follow-up, and no radiographic signs of pathology were seen. One of these implants showed a decrease in the ISQ from 67 to 53, which corroborates the findings of a recent clinical study on immediately loaded implants.[25] In spite of a slight rotation mobility, the other failed implant showed stable ISQ values, from 64 to 63. This implant was not removed and will be reevaluated at a later checkup visit. The lack of correlation between rotation mobility and RFA may be explained by the nature of the RFA test. RFA measures implant stability in lateral directions and does not depend on a structural interlock between the implant surface and bone tissue.[26] This is in contrast to implant torque resistance, which is linear, depending on the degree of interlock.[27] The interlock process requires bone growth onto the implant surface, whereas implant placement in nonviable bone or, in fact, any material can result in lateral stability and high ISQ numbers.

In conclusion, clinical experience with the first 200 consecutive oxidized implants in various reconstruction situations shows a successful outcome, with only three failures during a mean follow-up period of 30 months.

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