RFA Values of Implants Placed in Sinus Grafted and Nongrafted Sites after 6 and 12 Months

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ABSTRACT

Background: Maxillary sinus floor elevation surgery is widely used as a preimplantology method to permit implant insertion. Nevertheless, very few data are available about long-term stability of dental implants inserted in grafted sites.

Purpose: The aims of the present study were to evaluate the evolution of resonance frequency analysis (RFA) values at 6 and 12 months from the implant insertion in sinus grafted sites and nongrafted sites.

Materials and Methods: In 14 patients, 80 Xive implants (Dentsply Friadent GmbH, Mannheim, Germany) were inserted. Sixty-three implants were inserted in a site previously treated with a sinus lift; 17 implants were inserted in healed or postextraction sites. For each implant diameter, length, bone density, insertion torque, and percentage of implant fixed to a nongrafted bone were recorded. RFA values at implant insertion after 6 and 12 months were recorded.

Results: After 6 and 12 months, grafted sites showed higher RFA values than the control sites; after 12 months, the difference was statistically significant (.007). A statistically significant positive correlation was found between resonance frequency values and bone quality after 12 months (.05). No statistically significant correlation between RFA values and all the other variables considered was found.

Conclusions: Sites treated with sinus lift can offer good long-term stability. After 6 and 12 months, the geometric characteristics of the implant are no longer important to obtain high RFA values, and the bone–implant interface seems to be determinant.

KEY WORDS: bone–implant contact, dental implants, implant stability, resonance frequency analysis, sinus elevation

INTRODUCTION

Maxillary sinus floor elevation surgery with autogenous bone or bone substitute grafts is a reliable method to enable implant insertion in a severely resorbed posterior maxilla.[1] Implant stability is very important for the long-term success of implant therapy, and it has to be obtained at implant insertion and maintained over time. Some recent studies showed that this stability can be achieved at implant insertion in grafted and healed sites.[2,3] At this stage, implant features and geometric characteristics seem to be very important to obtain high resonance frequency analysis (RFA) values both in normally healed and grafted sites.

Nevertheless, at present, very few data are available about long-term stability of dental implants inserted in grafted sites and about differences between these and bone native sites. Moreover, after implant osseointegration and bone remodeling, the grafted bone–implant system is very different to that present at implant insertion surgery time, and the stability is quite probably dependent on the quality of the bone–implant interface.[4] So, it is probable that different factors are important in the determination of long-term international stability quotient (ISQ) values.

The aims of the present study were to evaluate the evolution of RFA values at 6 and 12 months from the implant insertion in sinus grafted sites and nongrafted sites, and also to evaluate the correlation between these values and different clinical factors.

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MATERIALS AND METHODS

Patients

In the period between July 2003 and December 2004, 14 patients (five males, nine females, age ranging from 40 to 66) who needed a maxillary rehabilitation were selected. Informed written consent to use their data for research purposes, approved by the Ethics Committee of the University of Chieti, Pescara, Italy, was obtained from the patients.

Exclusion criteria were as follows: a high degree of bruxism, smoking more than 20 cigarettes per day and excessive consumption of alcohol, localized radiation therapy of the oral cavity, antitumor chemotherapy, liver pathologies, hematic nephropathies, immunosupressed patients, patients taking corticosteroids, pregnant women, inflammatory and autoimmunity diseases of the oral cavity, and poor oral hygiene.

Implants

In 14 patients, a total of 80 Xive implants (Dentsply Friadent GmbH, Mannheim, Germany) were distributed as follows: 63 implants were inserted in a site previously treated with a sinus lift (group A), whereas 17 implants were inserted in nongrafted sites (group B). In group B, 13 implants were inserted in healed sites and four in postextraction sites.

Surgical Technique

Where needed, a sinus lift was performed with a combination of 50% autogenous bone and 50% deproteinized bovine bone mineral (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland). The implants were inserted in grafted sites after 6 months of uneventful healing time; 52 of group A implants were inserted according to a two-stage procedure and 11 with a one-stage procedure. In group B, nine implants were inserted with a two-stage procedure, whereas eight implants were inserted using a one-stage procedure.

Antimicrobial prophylaxis was obtained with 500 mg of amoxicillin twice daily for 5 days starting 1 hour before surgery. Local anesthesia was induced by infiltration with articaine/epinephrine, and postsurgical analgesic treatment was performed with 100 mg nimesulid twice daily for 3 days. Oral hygiene instructions were provided.

After a crestal incision, a mucoperiosteal flap was elevated. All the implants were inserted according to a strict protocol following the manufacturer's instructions. The sutures were removed 14 days after surgery.

Data Collection

Before surgery, radiographic examinations were done with the use of periapical radiography, orthopantomographs, and computed axial tomography (CAT) scans. During surgery for each implant, the following data were collected: implant diameter; implant length; bone density (assessed using preoperative radiographs and during drilling, according to the classification by Lekholm and Zarb[5]); insertion torque, recorded by an electronic instrument (Dentsply Friadent Frios®, Unit E, Mannheim, Germany) during low-speed insertion; and the RFA value with the ISQ scale, by means of a transducer attached to the implant via a screw and a frequency response analyzer (Osstell™ Device, Integration Diagnostic AB, Sävedalen, Sweden). According to the procedure described by Meredith and colleagues,[6] the transducer had a perpendicular orientation to the alveolar crest, and its upright beam part was placed on the palatal side.

For the implants inserted in an augmented site, the percentage of the implant fixed to the nongrafted bone was also recorded. For this purpose, a periapical radiograph was taken before the sinus lift, after 6 months, and immediately after the implant placement. The highest level of the recipient bone and the length of the implant that lay in the bone were then calculated. The measurement was rounded off to the nearest 0.1 mm. A peak Scale Loupe (GWJ Company, Hacienda Heights, CA, USA) with a magnifying factor of seven times and a scale graduated in 0.1 mm was used. Finally, the percentage was calculated.

In each patient, peri-implant crestal bone level was evaluated by calibrated examination of periapical X-rays. Measures were recorded after surgery and after a 12-month time period. The measurements were carried out mesially and distally to each implant, calculating the distance between the edge of the implant and the most coronal point of contact between the bone and the implant. The bone level recorded just after the surgical insertion of the implant was the reference point for the following measurements. The measurement was rounded off to the nearest 0.1 mm. Again, a peak Scale Loupe with a magnifying factor of seven times and a scale graduated in 0.1 mm was used.

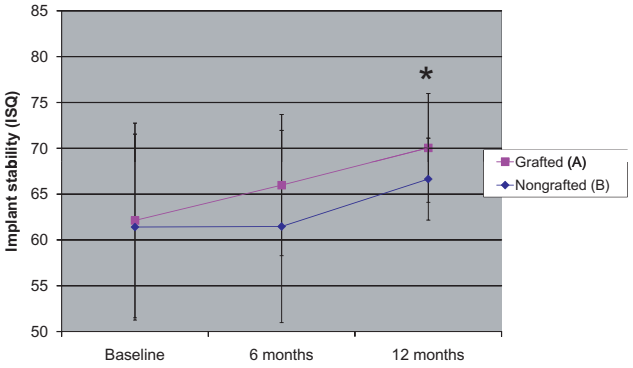

Figure 1 Graphic presentation of international stability quotient (ISQ) values for implants placed in grafted (group A) and nongrafted (group B) sites at baseline and after 6 and 12 months. Mean values ± SD. *Statistically significantly different between groups A and B, $p < .007$.

The RFA values were recorded again with the same technique after 6 (RFA_2) and 12 months (RFA_3) for all the implants.

All the measurements were performed by three independent examiners.

Statistical Analysis

A matrix of nonparametric correlation was used to explore possible association between the whole set of quantitative variables. Qualitative analyses were carried out by means of the Mann–Whitney *U* test. A further nonparametric model (linear regression or analysis of variance) was used to better explore the association between RFA values and any single variable of interest. A *p* value <.05 was considered significant.[7,8]

RESULTS

Implant survival was 100% after 12 months. No adverse reactions were recorded. The mean distance between the fixture/abutment junction and the bone crest was 0.3 ± 0.8 for group A and 0 ± 0.5 for group B at implant insertion. After 12 months, it was 1.4 ± 1.0 for group A and 1.0 ± 1.6 for group B. The difference was not statistically significant.

Results about RFA at implant insertion and the variables considered have already been presented in a previous publication.[3] The present study reports the baseline (RFA_1), 6- (RFA_2), and 12- (RFA_3) month registrations (Figure 1) as well as the correlation between RFA_2 and RFA_3 values, and the other variables are presented (Table 1).

Variables Related to the Surgical Site

The average ISQ value was 66.0 ± 7.7 after 6 months and 70.0 ± 5.9 after 12 months for group A, and 61.5 ± 10.5 after 6 months and 66.7 ± 4.5 after 12 months for group B. The differences were not statistically significant for RFA_2 values ($p = .06$), but the differences between RFA_3 values were statistically significant ($p = .007$).

No statistically significant correlations were found between RFA_2 and RFA_3 values and the percentage of the implant fixed to the nongrafted bone. Significant correlation between good bone quality and RFA_3 was found ($p = .05$).

Variables Related to the Implant

After 6 and 12 months, no statistically significant correlations were found between resonance frequency values and (1) implant diameter and (2) implant length.

Variables Related to Surgical Technique

No statistically significant correlations were found between RFA_2 and RFA_3 values and insertion torque. No

TABLE 1 Correlation between RFA_3 and All the Variables Considered

	$p \leq .05$ (Significant)	$p > .05$ (Nonsignificant)
Implant-related variables		Diameter
		Length
Surgical site-related variables	Sinus lift	Percentage of implant fixed
	Bone quality	in native bone
Surgical technique-related variables		Insertion torque
		One- or two-stage technique
		Diameter of the last bur used

No statistically significant correlations between variables considered and RFA_2 values were found. RFA_2 = resonance frequency analysis after 6 months; RFA_3 = resonance frequency analysis after 12 months.

statistically significant correlation between RFA_2 and RFA_3 values and the diameter of the last bur used was found at implant insertion. No significant correlations between RFA_2 and RFA_3 values and the one- or two-stage technique were found.

DISCUSSION

The use of sinus lift procedures is well documented, and it can provide adequate bone support for dental implants in patients that present a loss of bone height in the posterior maxillary regions.[1] Nevertheless, very few studies were carried out to understand if the bone grafted during a sinus lift is able to assure a good primary stability during implant insertion and if it is able to maintain this stability after 6 or 12 months.

A previous study[3] on the same pool of implants demonstrated that grafted bone can offer a good primary stability to the implants and that, during the surgical procedure, only a few mechanical characteristics of the implants (length and diameter) were able to influence the ISQ values.

The present study examined the same implants 6 and 12 months after their installation, exactly at the time of the second surgery (for the implants inserted with a two-step procedure) and after 6 months after the final restoration. RFA values after 6 months showed that the grafted sites provide good stability to implants and that on the average, they are better than group B sites. This difference is still present after 12 months and it is also statistically significant.

The presence of high RFA values in sinus grafted sites after 6 or 12 months of follow-up is consistent with two other studies carried on recently.[9,10] In the first study, Lundgren and colleagues evaluated the ISQ values of implants inserted at the same time of a sinus lift without any bone graft: mean values recorded at the time of surgery (65 ISQ), after 6 months (66 ISQ), and 12 months (64 ISQ) are very similar to our findings and showed that primary and long-term stability are good. The second is an animal study carried out to verify the quality of primary stability and bone–implant contact on implants inserted at the time of a sinus lift with and without bone graft. ISQ values reported after 6 months from the surgery are quite high (range between 64 and 67.6) and similar to those reported in the present study.

Long-term stability is also reported by Hallman and colleagues[11]: in this study 108 dental implants were placed after 6 months of a sinus floor augmentation with a mixture of autogenous and deproteinized bovine bone; after 3 years of loading, the implant stability was recorded using an Osstell instrument (Integration Diagnostic Ltd., Sävedalen, Sweden). The mean RFA values reported were 67.4 ± 4.5 for residual bone and 65.6 ± 3.8 for the augmented sites. Again, ISQ values are very similar to our findings, even after 2 more years of follow-up.

Unlike the present study, none of these cited papers report a statistically significant difference of long-term RFA values between grafted or nongrafted sites. This finding could be explained by the presence in the control group of postextraction sites: a recent study[12] showed that implants placed in fresh extraction sites, even in the presence of a high mean ISQ value, can present a wide range of ISQ quotient (45–75). Moreover, according to the study by Friberg and colleagues,[13] the higher results found in the grafted sites could be explained by the nature of RFA technique, where the crestal third of the implant site seems to be the most important for the determination of ISQ values at least in machined parallel-walled implants. In fact, unlike postextraction sites, the grafted sites always maintain the cortical native bone, which probably reacts better to implant insertion in long-term evaluation. Finally, the increase of RFA values with time in all sites seems to suggest a role of bone/graft maturation after implant insertion.

In a previous study on the same implant sample, Degidi and colleagues[3] reported a statistically significant positive correlation between RFA values and implant length and diameter; after 6 and 12 months of observation, this correlation is not significant anymore. This result suggests that at the insertion, the geometric characteristics of the implants are determinant to obtain a good primary stability and so a high ISQ value, but after the bone remodeling that takes place during the early phase of osseintegration,[4] these factors are not important and the bone features are more influential. This result is consistent with a recent study[14] that showed a strict correlation between RFA values and bone–implant contact. Moreover, recently Huwiler and colleagues[15] studied the RFA changes during the early phase of osseointegration: the authors reported a progressive decrease of the mean ISQ value to a minimum after 3 to 4 weeks and a subsequent progressive increase during the following 8 to 9 weeks of observation. During these 12 weeks, no correlation was found between ISQ values and bone volume density or bone trabecular connectivity.

The correlation between RFA_3 values and good bone quality reported by the present study seems to confirm the different importance of factors determining RFA values at implant insertion and after 6 and 12 months. In fact, good quality bone probably reacts better to implant insertion, and after the bone remodeling, the stability of the implant could be higher. Unfortunately, no more data are available at the moment about the importance of bone quality in the determination of long-term RFA values, so more studies have to be carried out.

CONCLUSIONS

Within the limitation of the present study, the results showed that a site that has undergone a sinus lift can assure good long-term stability after 6 and 12 months from implant insertion surgery. After osseointegration, the geometric characteristics of the implant are no longer important to obtain high RFA values and the bone–implant interface seems to be determinant.

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