Vol. xx No. x Month 2012

The predictors of implant failure after maxillary sinus floor augmentation and reconstruction: a retrospective study of 1045 consecutive implants

Max J. Zinser, MD, DDS,[a] Peter Randelzhofer, DDS,[b] Luit Kuiper, DDS,[c] Joachim E. Zöller, MD, DDS, PhD,[a] and Gert L. De Lange, DDS, PhD[b]

Objective. To assess the predictors of implant failure after grafted maxillary sinus (GMS).
Material and Methods. A total of 1045 implants were inserted in 224 patients/347 GMS during a period of 14 years. Kaplan-Meyer and multivariate log-regression analysis were used to assess the following variates: patient's age, gender, smoker/nonsmoker, American Society of Anesthesiologists (ASA) class, one/two-stage surgery, merged/submerged healing, membrane, antibiotics, auto/allo/xenogenic bone grafts, implant's lengths/surface/diameter, crestal bone atrophy/quality, implant region, prosthetics, opposing dentition, and implant proximity to evaluate the predictors and relative risk (hazard ratio [HR]) of implant failure.
Results. Significant implant failure predictors were the graft material (HR = 4.7), with superior results for autogenic bone, residual crestal bone height (HR = 3.51), ASA class (HR = 2.73), surgical technique (HR = 2.56), implant proximity (HR = 2.07), smoker (HR = 1.98), and age (>60/HR=1.39). All other factors were insignificant. Overall survival rate was 93.3%.
Conclusions. GMS is effective when the predictors are considered. Patient selection, including the ASA status, smoking, residual bone height, and the graft material are the predominant predictors. In highly atrophic situations, autogenic bone grafts showed superiority; however, in less atrophic cases, nonautogenic bone-grafts are equivalent. (Oral Surg Oral Med Oral Pathol Oral Radiol 2012;xx:xxx)

Restoration of the atrophic posterior maxilla with dental implants is a routine procedure that uses innovative surgical applications involving the maxillary sinus, with implant survival rates of more than 90% over 3 to 5 years.[1-3] The primary implant stability can be challenged by the pneumatization of the maxillary sinus after tooth loss and consecutive reduction of the vertical and horizontal height of the alveolar ridge, increased maxilla-mandibular relation, and the medullary/spongy quality of the bone with thin cortices and reduced strength.[4]

When the bone height of the maxillary sinus is <10 mm, conventional implant techniques may not provide adequate stabilization for implants of standard diameters and lengths.[5] The residual bone height of the maxillary sinus determines the surgical augmentation technique, with success rates varying between 85.4% and 100%, according to the class of atrophy, as shown by Chiapasco et al.[6] The typical surgical protocols are the simultaneous one-stage lateral or crestal antrostomy, when the residual crestal bone is greater than 3 to 6 mm, or two-stage delayed procedure, recommended when the residual bone is less than 3 to 6 mm.[7] Furthermore, Marchetti et al[8] showed that the risk of implant failure is halved when the 2-stage technique is used.

In 1996, the Sinus Consensus Conference concluded that the sinus graft technique including the alveolar crest reconstruction with a 90% success rate is considered an effective therapeutic modality.[9] Whether implant survival rates are greater in augmented sites versus nonaugmented sites is contentious. Carr et al[10] reported that the risk of implant failure is 5 times greater in augmented sites, whereas Olson et al[11] reported a survival rate of 97.5% in grafted sinuses compared with 90.3% in nongrafted sinuses. Alternatively, the use of short implants has been considered, although when using this technique, the intermaxillary vertical and horizontal relation cannot be improved. The ques-

Statement of Clinical Relevance

This long-term study (14 years) assesses the predictors of implant failure following grafted and augmented maxillary sinus. The Kaplan-Meyer survival- and multivariate log regression analysis (Cox) indicates the clinical relevance, importance and relative risk of 18 different variates.

[a]Department of Cranio-Maxillofacial and Plastic Surgery, University Cologne, Cologne, Germany.
[b]Center of Oral Implantology and Periodontics, Amstelveen, the Netherlands.
[c]Department of Maxilllofacial Surgery, Hospital Amstelveen, the Netherlands.
Received for publication Jan 24, 2012; returned for revision Jun 10, 2012; accepted for publication Jun 14, 2012.

2212-4403/$ - see front matter
http://dx.doi.org/10.1016/j.oooo.2012.06.015

tion of whether shorter implants are associated with greater failure rates is still disputed. In a multicenter study, Buser et al[12] showed that 8-mm implants demonstrated an 8-year cumulative success rate of 91.4%, compared with 93.4% for 10-mm implants and 95.0% for 12-mm implants. Sinus elevation with a large variety of different graft materials has been used.[13] There appears to be a correlation between the residual crestal bone height, the graft material, and the survival rate of the implant.

However, the impact of these variates on the implant survival rate is difficult to estimate.[14] Heterogeneity between and within studies has led to a wide range of results relating to the survival of implants in augmented maxillary sinus, e.g., using patient-based analysis variations of 36% to 100%, and for implant-based analysis variations between 75% and 100%[15] have been reported. Most other studies include too little data to enable a multivariate analysis. Therefore, meta-analyses are difficult and no general conclusions can be drawn.

Hence, the aim of the present study was to retrospectively analyze a database consisting of 224 patients who received 1045 implants in 347 GMS in the augmented posterior maxilla, and to assess the significant predictors including the relative risk (hazard ratio [HR]) of implant failure over the course of 14 years by using the Kaplan-Meier survival function and a multivariate log regression analysis. Systematically, the following variates were included in the multivariate log-regression analysis: patient's age, gender, smoking status, ASA class, one/two-stage surgery, merged/submerged implant healing, use of a membrane, antibiotics, auto/allo/xenogenic bone grafts, implant's lengths/surface/diameter, the residual crestal bone height and bone quality, the region of implantation, prosthetics, opposing dentition, and implant proximity.

MATERIAL AND METHODS

In the present retrospective study, data were analyzed from 224 patients who received 1045 implants in 347 GMS at the Academic Center of Implantology Amstelveen and the Department of Maxillofacial Surgery Hospital Amstelveen in Holland between 1995 and 2009.

This time period of 14 years provided an ideal opportunity for the observation of long-term survival rates. One hundred twenty male and 104 female patients, age from 35 to 81 years (mean 56.13 years), were included in the study. The patients presented with partially or totally edentulous maxillae associated with various degrees of vertical and horizontal atrophy of the alveolar crest and sinus pneumatization (Cawood II-VI) that did not allow the placement of implants of adequate dimensions (Figs. 2, 3).

Only patients with a complete radiologic examination, including panoramic radiographs and lateral cephalograms, a complete clinical follow-up, and having no signs and symptoms of maxillary sinus disease and insufficient bone volume in the lateral-posterior maxilla to place endosseus implants at least 9 mm long and 3.3 mm wide were included in this study. Patients with incomplete records, a history of radiochemotherapy in the head and neck region, noncompensated diabetes, active periodontal disease involving the residual dentition, mucosal disease, and poor oral hygiene were excluded.

One hundred five patients presented with total edentulism of the maxilla, with 97 having bilateral defects and 8 with unilateral defects. One hundred nineteen patients had partial maxillary edentulism (63 monolateral and 56 bilateral). Opposing arch dentition was represented by natural dentition in 170 GMS, fixed prosthesis (crowns, bridges) supported by natural dentition in 31 GMS patients, and fixed implant supported prostheses in 45 GMS patients. One hundred one GMS had partial or completely removable overdentures. In 45 GMS they were implant supported and in 56 GMS natural teeth supported them.

Diagnosis and treatment planning

Atrophy of the lateral-posterior maxilla and the residual crestal bone height was classified according to Cawood et al's[16] subsummizing classes I-VI. Therefore, in almost all cases an orthopantomogram and lateral cephalogram were used; there are only a few cases where a CBCT (cone beam computed tomography) was used.

The type of surgical correction of the atrophied maxillae was determined by the initial clinical and radiographic evaluation and differed according to the class of atrophy. Patients with a crestal bone height greater to or equal than 10 mm (Cawood I) were treated with an osteotome procedure (internal sinus augmentation) and were not included in this study. However, in some patients who showed laterobuccal atrophy of the alveolar crest, the radiologic determination of the lengths using 2D X-rays was misleading because f overprojection and overlapping. Consequently, the final treatment plan was decided in vivo when the alveolar crest and bone quality could be seen and the lengths were determined using a pilot drill. Furthermore, it must be mentioned that in Cawood II situations in the past, more GMS procedures were performed than now. There could be a paradigm shift seen from longer toward shorter implants.

In cases with a crestal bone height between 7 and 11 mm, showing a medium posterolateral atrophy (Ca-