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Analysis of implant-failure predictors in the posterior maxilla: A retrospective study of 1395 implants

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ABSTRACT

The aim of this study was to analyze predictors for dental implant failure in the posterior maxilla.

A database was created to include patients being treated with dental implants posterior to the maxillary cuspids. Independent variables thought to be predictive of potential implant failure included (1) sinus elevation, (2) implant length, (3) implant diameter, (4) indication, (5) implant region, (6) timepoint of implant placement, (7) one-vs. two-stage augmentation, and (8) healing mode. Cox regression analysis was used to evaluate the influence of predictors 1–3 on implant failure as dependent variable. The predictors 4–9 were analyzed strictly descriptively.

The final database included 592 patients with 1395 implants. The overall 1- and 5-year implant survival rates were 94.8% and 88.6%, respectively. The survival rates for sinus elevation vs. placement into native bone were 94.4% and 95.4%, respectively ($p = 0.33$). The survival rates for the short (<10 mm), the middle (10–13 mm) and the long implants (>13 mm) were 100%, 89% and 76.8%, respectively (middle-vs. long implants $p = 0.62$). The implant survival rates for the small- (<3.6 mm), the middle- (3.6–4.5 mm) and the wide diameter implants (>4.5 mm) were 92.5%, 87.9% and 89.6%, respectively ($p = 0.0425$).

None of the parameters evaluated were identified as predictor of implant failure in the posterior maxilla.

1. Introduction

Dental implantation in the edentulous patient is widely recognized as a successful procedure with predictable outcomes when performed on sites with normal bone volume and mechanical quality such as is typical in the interforaminal region of the lower jaw, for example.

There exist numerous new developments and techniques in dental implantology, which continuously improve the outcomes, such as nano-crystalline diamond-coated titanium implants, fluoridated implants and platelet-rich fibrin (PRF) as sole grafting material (Metzler et al., 2013; Dasmah et al., 2014; Jeong et al., 2014).

Nevertheless, the implant-supported masticatory restoration of the posterior maxilla represents a specific challenge, due to specific anatomical and biological conditions. Reduced residual bone volume after tooth loss in combination with poor bone density, as well as its proximity to the maxillary sinus, are common limitations that influence implant placement in the posterior maxilla, especially if the tooth loss occurred a long time ago (Morand and Irinakis, 2007). Consequently, the atrophic posterior maxilla has been a challenge to restore with dental implants for an extended period of time (Schmidlin et al., 2004).

A number of innovative surgical procedures are well established for successful bone management with consecutive implant placements in the posterior maxilla:

Sinus elevation represents the surgical approach most commonly used to increase the vertical amount of bone in the posterior maxilla, and it carries predictable implant survival rates of more than 90% over 3–5 years (Jensen et al., 1996; Khoury, 1999;

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Huynh-Ba et al., 2008; Zinser et al., 2013). However, a highly-controversial issue is whether implant survival rates are higher in augmented sites versus non-augmented sites (Zinser et al., 2013). Some have described that implants positioned in augmented bone are five times more likely to fail than implants placed in non-augmented sites (Carr et al., 2003), while others have found an implant survival rate of 97.5% for implants in grafted sinuses, compared to 90.3% survival rate for implants placed in the posterior maxilla in native bone (Olson et al., 2000; Zinser et al., 2013). Other studies comparing implants placed in grafted sinuses to implants placed in the anterior maxilla found comparable survival rates (Tidwell et al., 1992; Blomqvist et al., 1996).

Since augmentation procedures are also associated with complications, many authors advocate the optimal utilization of pre-existing, native bone. Angled placement of implants in cases with which only limited residual bone volume in the posterior maxilla is available (Del Fabbro et al., 2004), while short (<10 mm) and reduced diameter implants (<3.6 mm) may be used as well. A potential risk factor for implant loss may be narrow diameter implant size which limits the magnitude of occlusal forces that are acceptable (Romeo et al., 2010). The question of whether shorter implants are associated with higher failure rates is still contested (Zinser et al., 2013). Renouard and Nisand performed a study analyzing the survival rates of short implants (6–8.5 mm) in the severely atrophied maxilla and found the cumulative 2-year survival rate to be 94.6%. The authors concluded that short implants may be used for prosthetic fitting in the severely atrophied maxilla as an alternative to complex surgical procedures (Renouard and Nisand, 2005), which is similar to other studies (Nedir et al., 2004; Anitua et al., 2008). Conversely, recent studies showed that shorter and reduced diameter implants have higher failure rates compared to longer and wider implants, and therefore should be used only for selected indications (Bergendal and Engquist, 1998; Winkler et al., 2000; Ferrigno et al., 2002). Buser et al. designed a multicenter study to detect the impact of implant length on implant survival rate. The authors demonstrated that short 8 mm implants had an 8-year cumulative success rate of 91.4%. By comparison, 10 mm and 12 mm implants had success rates of 93.4% and 95.0%, respectively (Buser et al., 1997). Therefore, no general conclusions can be made regarding sinus elevation or the use of short and reduced diameter implants as predictors of implant failure in the posterior maxilla. However, the need to identify predictors associated with implant failure in the posterior maxilla is becoming increasingly important, especially in light of the rising rate of dental implantat procedures.

The aim of this retrospective study was to identify predictors of implant failure for implants placed in the posterior maxilla.

2. Materials and methods

2.1. Data collection

A database was created including all patients who received one or more implants in the posterior maxilla posterior to the cuspids in the period from January 2002 to December 2007, at the Department of Oral and Maxillofacial Surgery of the University Medical Center Mainz. The criterion for study inclusion was that the posterior maxillary implant placement had to have been performed in our department. Exclusion criteria included patients with a history of head and neck cancer in whom implants were placed in the reconstructed maxilla as well as patients with large block augmentation procedures from the iliac crest. Multiple implant systems were used in the study.

Subjects were identified by searching the electronic dental record systems (VISIdent, BDV Branchen-Daten-Verarbeitung GmbH, Holzwickede, Germany; DOCconcept Praxis 5.00, DOCexpert Gruppe, Bamberg, Germany; SIDEXIS, Sirona Dental Systems GmbH, Bensheim, Germany; impDAT 3.04 Dental-Software, Kea Software GmBH, Pöcking, Germany).

Reflecting the recommendations of the German Society for Dental and Oral Medicine (DGZMK), the information retrieved from the dental records was divided into *independent (continuous and categorical) patient-, bone- and implant-related variables*, in order to ensure adequate description of the data (Schliephake and Neukam, 2000).

Patient-related variables included patient age (years) at implant placement, gender, and the indication (edentulous maxilla, saddle area >1 tooth unit, free-end gap, single tooth replacement) were also recorded. A specific sub-classification for a single-tooth replacement in a free-end gap situation has not been performed.

The two *bone-related variables* included type of bone (native bone or sinus elevation) and one-vs. two-stage augmentation.

Eight *implant-related variables* included implant placement (time after tooth extraction, time of implant failure), implant region (first premolar, second premolar, first molar, second molar, third molar), implant system, implant length (<10 mm, 10–13 mm, >13 mm), implant diameter (<3.6 mm, 3.6–4.5 mm, >4.5 mm), healing mode (submerged, transmucosal), uncovering time, and data for the survival function (date of the last recall, state of the implant: in situ vs. lost).

The primary endpoint of this study was implant failure (*dependent variable*). Implant failure was defined as the removal of an implant for any reason (Zinser et al., 2013). An implant was considered successful when it remained *in situ* at the time of most recent follow-up, with no indication for removal (e.g., clinical mobility, pain, infection) and no radiographic evidence of peri-implant osteolysis or implant fracture (Naert et al., 1992).

Implant survival was ascertained from the dental records, or directly from clinical evaluations and radiographs. If no recall radiograph was available, the patient was called in for a recall visit, which included clinical evaluation of implants, as well as radiographs when indicated. During the recall visit, implant survival was evaluated based on the criteria mentioned above.

2.2. Statistical analysis

Initially, *descriptive statistics* were calculated for all independent variables. After a review of the literature, the following three predictors seemed to be very important for an implant failure and were regarded with particular attention: (1) sinus elevation, (2) implant length, and (3) diameter. Further focus was given to the predictors: (4) indication, (5) implant region, (6) implant placement, (7) one-vs. two stage augmentation, and (8) healing mode. The 1- and 5-year survival rates of the implants were analyzed using *Kaplan–Meier* estimates. The survival time of an implant was defined as the time between implantat placement and removal for any reason, or to the time of last follow-up, whichever came first.

Cox regression analysis was performed to determine the single contribution of the predictors 1–3 on implant failure, and to identify the statistical value of these predictors with a global significance level of $p \leq .05$. As a result of the multiple testing, a Bonferroni-correction with a local significance level of $p = 0.0167$ (0.05/3) was implemented. P-values $\leq$0.0167 were regarded as statistically significant. The analysis of predictors 4–8 was performed strictly *descriptively*. To accommodate correlation analysis of patients with multiple implants, we introduced a patient frailty term within the Cox regression analysis.

The statistical analysis was carried out with Microsoft Excel (Microsoft Office 2007), SPSS (version 15.0 for MS Windows), and with R (version 2.12.0 for MS Windows).