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Evaluation of bone resorption in fibula and deep circumflex iliac artery flaps following dental implantation: A three-year follow-up study

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ABSTRACT

Long-term results of dental implant treatment in fibula free and deep circumflex iliac artery (DCIA) free flaps are scarce. The purpose of this study was to assess and compare peri-implant bone resorption of vascularized bone flaps treated with dental implants. A total of 28 patients, 14 fibula and 14 DCIA flaps, respectively, underwent reconstruction of the lower and upper jaw by the use of vascularized bone flaps and were treated with dental implants. Peri-implant bone resorption was measured using digital panographs up to 3 years. Radiographic pictures were taken immediately after implant surgery before prosthetic rehabilitation (T0), the second after 6–12 months (T1), the third after 13–24 months (T2), and the fourth after 25–36 months (T3). Over a period of 3 years, implant resorption changed significantly over time ($p_{D1} = 0.0113$, $p_{D2} = 0.0232$, $p_{D3} = 0.0143$). However, a significant difference in overall resorption between implants with fibula flaps and DCIA could not be detected for the patient average or within the implant-level analysis. Flaps presented minimal resorption from beneath (mean resorption DCIA 0.65, fibula = 0.26). Strong peri-implant bone resorption changed significantly over time. However, no significant difference was observed between fibula and DCIA flaps.

1. Introduction

The treatment of large bone defects after a resection, caused by tumors, cysts, or osteomyelitis bone infections, is a challenging task. The stability of the bone volume is the determining factor, not only for graft and implant survival and success, but also for the masticatory function and esthetic profile. Microvascular bony flaps represent a reliable treatment option for reconstruction in cases of large jaw defects with low graft resorption in the early healing phase (Mertens et al., 2013). The iliac crest and fibula are all well-established donor sites (Taylor et al., 1975; Riediger, 1988; Hidalgo, 1989). It is evident that fibular flaps show both short- and long-term stability (Holzle et al., 2007). Nonvascularized bone grafts and local flaps are appropriate for reconstruction of small defects. Because of vascularization of the flaps, bone dimension remains steady, with a lower resorption rate compared to that of nonvascularized bone grafts (Binger and Hell, 1999; Li et al., 2007). Several authors have reported that nonvascularized bone grafts, especially from the iliac crest, show high resorption rates (Vermeeren et al., 1996; Johansson et al., 2001; Mertens et al., 2013).

Nevertheless, most patients are looking for a complete rehabilitation after bone and continuous jaw defects, and desire an esthetic and fixed dental rehabilitation. Regarding the implant treatment, bone stability and a sufficient bone volume to retain dental implants are important factors (Rana et al., 2011). Different problems such as bone resorption and soft tissue inflammation around titanium implants inserted in different bone grafts or in different microvascular flaps are described in the current literature (Verhoeven et al., 2006; Ciocca et al., 2008; Lizio et al., 2009; Anne-Gaelle et al., 2011; Chang et al., 2011; Wang et al., 2015). Soft tissue

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may change dramatically, given that tumor resection gingiva has to be replaced with osteomyocutanous flaps. Free gingival grafts represent a possible treatment for rebuilding attached areas; however, large areas constitute a challenging task.

So far, there are only very limited published data from clinical investigations regarding the contrast of long-term bone resorption around dental implants comparing fibular free and the deep circumflex iliac artery (DCIA) flaps; it is of great significance to see further long-term, science-based clinical results.

The aim of this retrospective study is to evaluate bone levels around implants, specifically comparing the fibular free flap and the DCIA flap up to 3 years after implantation.

2. Materials and methods

2.1. Study population

Patients having received re-anastomosis microvascular bony flaps were included in this study. All patients who were treated with dental implants that were inserted in fibula-free or DCIA flaps during the study period and came to the follow-up assessments without any malignant relapses were included. Patients with smoking habits and bony reconstruction who had undergone radiotherapy after dental implantation were excluded from this study. Finally, 28 patients, 14 with fibula and 14 with DCIA flaps, were recruited for this retrospective cohort study, having a total of 109 implants. The Ethics Committee of the local Medical Faculty University reviewed and approved the study protocol. The study was conducted in accordance with the principles of the Declaration of Helsinki.

2.2. Implant treatment

Six to nine months after reconstructive surgery was performed, the osteosynthesis plate and screws were removed if the general and oncologic situations permitted. All 109 implants were inserted in a two-stage surgical approach in a total of 28 patients. Straumann (Straumann AG, Switzerland, Basel) and Camlog (Camlog AG, Switzerland, Basel) titanium implant designs were used.

After 3 months of implant healing, second-stage surgery was performed and the soft tissue situation was re-evaluated. When required and applicable, additional soft tissue surgery was performed in terms of vestibuloplasty with either split-thickness skin grafts or free gingival grafts from the palate. Finally, prosthodontic rehabilitation was performed after a mean time of 3.3 (±0.2) months.

2.3. Data collection

For the evaluation of bone resorption, digital panoramic radiographs (Sirona, Bensheim, Germany) were performed for the investigation. The radiographs were taken at the following times: the first evaluation was performed after implant surgery before prosthetic rehabilitation (T0), the second after 6–12 months (T1), the third after 13–24 months (T2), and the fourth after 25–36 months (T3). For calibration of the radiographic images, the defined distance of the individual implant length was used. Cylindrical implants with standardized and quality controlled manufacturing dimensions are ideal for such calibration purposes in radiographs. Moreover, a potential magnification during image acquisition has not had any significant influence.

In Fig. 1, all measured distances are presented. Peri-implant bone resorption (D1) was recorded by comparing panoramic radiographs taken after implant placement, at the time of prosthesis delivery, and at the follow-up assessments.

Measurements between the top of the implant shoulder and the most coronal level of the direct bone-to-implant contact were made mesial and distal to each implant.

Vertical bone height (D2) was measured between the bone to the implant contact point and the lowest margin of the reconstruction. Distance 2 was evaluated parallel to the adjacent implant on both sides of the implant. Distance 3 (D3) represents the vertical bone height beneath each implant to the basal bone. The implant length (Distance 4, D4) was used for calibration. Dimensional distortion between the different panoramic radiographs was corrected with the actual implant dimensions. One observer performed all measurements three times on different days, with a maximal distance of 10 days between measurements. The mean value of these three measurements was used for the statistical analysis to account for data variation. Additionally, the survival rate of the implants was evaluated for all patients (Fig. 1).

For digital measurements on the images we used the software MB-Ruler (EOS-Metrology, Heidenheim, Germany). This software allowed placement of the endpoints of the distance measurements in enlarged pictures with the aid of a loupe function with a 2–16× magnification.

2.4. Statistical analysis

All continuous variables are expressed as mean ± standard deviation (SD), while categorical variables are expressed as absolute frequencies and percentages. For heavily skewed distributions the median, the 0.25-quantile (Q1), and the 0.75-quantile (Q3) were used instead. The repeatedly measured distances D1 to D4 were evaluated using the differences between the baseline measurement (T0) and the corresponding time points Ti ($i = 1, 2, 3$). For each patient, the mean value of the differences of all of his/her implants was used for data analysis on the patient level. These mean differences of each patient k at time Ti of distance Dj ($j = 1, 2, 3, 4$) will be denoted by d_{jik} and represent our primary outcomes. Since the differences d_{ijk} were not normally distributed, an exact Wilcoxon signed rank test was used to compare the fibula with the DCIA. Box plots were chosen to present the fluctuations of selected factors over time. Because this is a retrospective study, measurements at the later time points are missing due to missing radiographs. The number of patients included in the analysis is given in the corresponding analysis.

A linear model with repeated measures was applied for all distances Dj to evaluate the resorption of vascularized bony flaps on implant level over time. For each distance Dj, the difference between the baseline measurement (T0) and the corresponding time points Ti ($i = 1, 2, 3$) for each implant was treated as dependent variable. To account for the dependence between implants of the

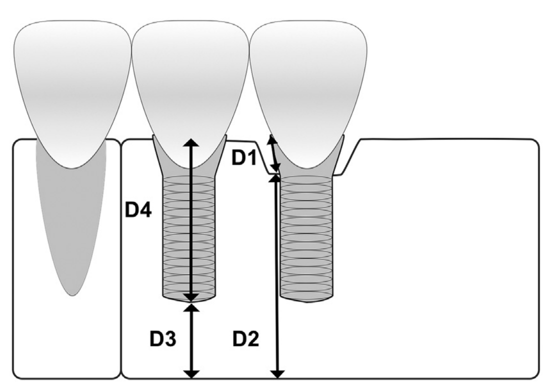

Fig. 1. Measured distances on radiograph.