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Intraosseous stability of dental implants in free revascularized fibula and iliac crest bone flaps

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ABSTRACT

The aim of this study was to investigate the influence of two different microvascular reanastomized bone transplants on primary (PS) and secondary stability (SS) of dental implants. Totally 96 implants (Bone Level, Institut Straumann AG, Basel, Switzerland) were inserted in fibula ($n = 50$) and iliac crest ($n = 46$) in mean of 97.7 SD 75.6 weeks after performing reconstructive surgery. For measuring PS and SS the resonance frequency (RFA) analysis was used in mesiodistal and vestibulo-oral direction to quantify the implant stability quotient (ISQ). Mean values (ISQ) for PS in fibula was about 79.48 SD 2.41 and in iliac crest 61.10 SD 3.34 as well as SS in fibula was about 75.59 SD 5.10 and in iliac crest 73.63 SD 5.34. Statistically significant differences between both flaps were found for PS in mesiodistal and vestibulooral direction ($p < 0.001$). Between the primary and SS a significant decrease was recognized in fibula flap ($p < 0.01$) as well as an increase in iliac crest flap ($p < 0.001$). Statistically no difference was found between both bone flaps for SS ($p = 0.076$). The implant stability in fibula and iliac crest flap after osseointegration is similar to each other. Therefore, it is not important for choosing the suitable donor side.

1. Introduction

Segment defects of the maxilla or mandible as a result of severe atrophy, trauma or tumor resection can lead to significant oral dysfunction and facial deformities. The reconstruction of the jaw can be done by the use of revascularized free flaps such as the iliac crest flap, fibula flap, and scapula flap that have been proposed for reconstructive procedures. Also non-vascularized grafts were used for reconstruction but they are limited by segmented continuity defect size, conditions at the recipient sites, and amount of soft tissue available to achieve sufficient graft coverage (Chiapasco et al., 2006). Additionally the non-vascularized bone grafts are marked by high resorption rates up to 49.5% within 6 months after grafting (Vermeeren et al., 1996; Johansson et al., 2001; Mertens et al., 2013). In contrast, microvascular reanastomized bone transplants represent a reliable treatment option for reconstruction in cases of large defects of the jaw and show a low graft resorption especially in the early healing phase. Additionally, the grafts provide sufficient bone volume to permit implant rehabilitation (Mertens et al., 2014).

Implant stability is an important prerequisite for osseointegration and subsequently for successful implant treatment. A distinction is made between primary and secondary stability. Primary stability is based on the mechanical engagement in bone immediately after implant insertion, and secondary stability is determined after bone regeneration and remodeling. A high primary stability is directly associated with the secondary stability (Davies, 1998). Different investigations have shown the various numbers of influencing factors affecting primary stability (Romanos, 2009). These include next to the macro- and microdesign of an implant, the surgical technique of implant site preparation and also the quantity and density of local bone (Friberg et al., 1995; O'Sullivan et al., 2000; Akkocaoglu et al., 2007).

Predictable outcomes of implants placed into vascularized bone grafts have been reported for jaw reconstruction (Chang et al., 1998; Chana et al., 2004). But implant stability in microvascular reanastomized bone transplants should be taken into consideration

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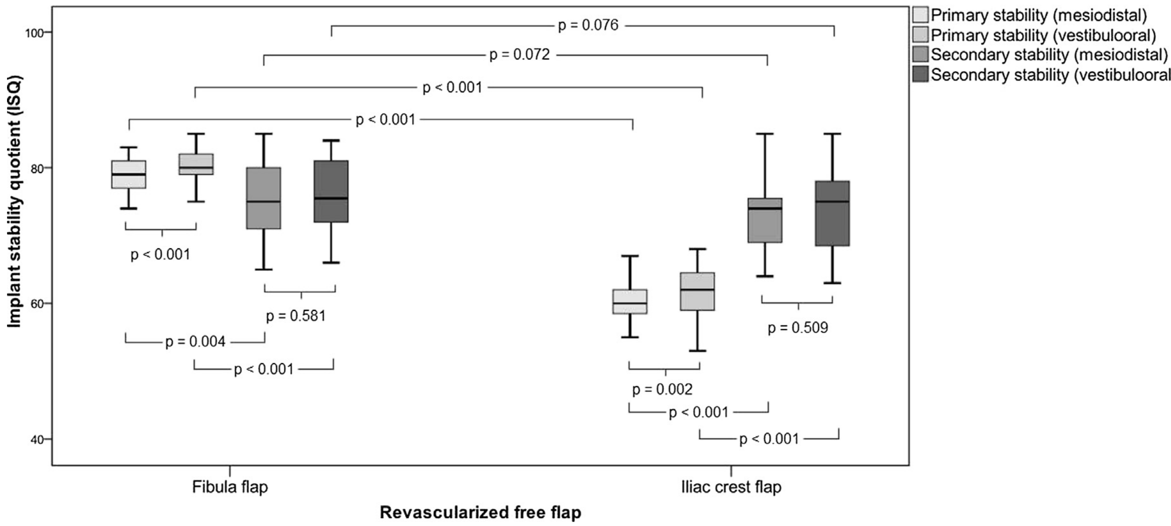

Fig. 1. Boxplot of mean values, standard deviations (SD) and comparisons of primary and secondary stability of dental implants in fibula and iliac crest flap.

to achieve the best possible conditions for osseointegration. Impaired primary implant stability, particularly related to poor bone quality, can jeopardize the osseointegration process and lead to reduced secondary stability up to failure and implant loss (Roos et al., 1997).

Next to the surgical subjective perception, insertion torque values or the periotest, the resonance frequency analysis (RFA) is a noninvasive instrument for dental implant stability measurements with *in vivo* and *in vitro* studies (Meredith et al., 1997; Sakoh et al., 2006; Tozum et al., 2008; Turkyilmaz et al., 2009; Ohta et al., 2010). The value of implant stability quotient (ISQ) ranges from 1 to 100, where a high value (>60) indicates a high implant stability and vice versa. This technique allows the determination of implant stability decreases or increases, which cannot be perceived clinically, with good repeatability of the measurement results (Friberg et al., 1999; O'Sullivan et al., 2000; Nedir et al., 2004).

The aim of the current study was to evaluate the effects of free revascularized fibula and iliac crest donor sites on primary and secondary stability of implants by comparing quantitative implant stability measurements. This could have consequences for the timing of implant loading or the quality of the transplant.

2. Materials and Methods

2.1. Patients

In this study 26 patients [14 females and 12 males with a mean age of 51.8 years (range 21–77 years)] were recruited from the Department of Oral and Maxillofacial Surgery of the University Hospital of RWTH Aachen, Germany and were treated between October 2012 and May 2015 with a free revascularized flaps from the fibula or iliac crest and dental implants. 13 grafts were taken from the iliac crest as well as from the fibula. Indications for reconstruction were due to benign (iliac crest: 5, fibula: 9) or malignant entities (iliac crest: 6, fibula: 1), osteomyelitis (iliac crest: 2, fibula: 1) and extreme atrophy (fibula: 1) as well as one case of bullet wound (fibula: 1). All 7 patients with malignancies needed adjuvant radiotherapy. Afterward microsurgical reconstruction was done. The study was conducted in accordance with the principles of the Declaration of Helsinki. The Ethics Committee of the Medical Faculty of the RWTH Aachen reviewed and approved the study protocol (EK090/16).

2.2. Implant treatment

The implant insertions took place in mean 97.7 SD 75.6 weeks (range between 24.6 and 299.4 weeks) after performing reconstructive surgery (Figs. 2 and 3). The number and location of the inserted implants depended on the bone condition and the prosthetic treatment concept. All implants (Bone Level, Institut Straumann AG, Basel, Switzerland) were inserted in a two-stage surgical approach. A total of 104 implants were inserted, and about 96 into the bone transplant (iliac crest: 46, fibula: 50). After an implant healing period of about 20.6 SD 10.0 weeks (range between 8.3 and 46.9 weeks) a second-stage surgery was done for implant exposure. If necessary, at this time thinning of the flap or vestibuloplasty with split-thickness skin grafts or free gingival grafts from the palate were done. About 3 weeks after the re-entry the individual prosthetic treatment followed.

2.3. Resonance Frequency

The primary stability measurements were performed directly after implant surgery and the secondary stability measurements immediately before prosthetic loading by using resonance frequency analysis (RFA) with hand-screwed associated Smart Pegs (Type 53 and 54, Ostell, Gothenburg, Sweden). The ISQ ranged from 0 to 100 (measured between 3,500 and 8,500 Hz) and is divided for *in vivo* investigations into low (<60 ISQ), medium (60–70 ISQ), and high stability (>70 ISQ). For each specimen, the RFA measurement was repeated three times. Measurements were performed in two orientations, separated by a 90-degree angle (mesiodistal and vestibuloocral direction), and the average ISQ values were calculated.

2.4. Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences SPSS v23 (IBM, Chicago, IL, USA) running on Apple OS X v10.10.2 (Apple Inc., Cupertino, CA, USA). The Shapiro-Wilkes normality test and the Levene variance homogeneity test were applied to the data. The data were normally distributed, and there was homogeneity of variance among the groups. Student t-test was used for statistical analysis. The level of significance was set at $p \leq 0.05$. All data are expressed as mean values and standard deviation (SD).