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A 5-year prospective radiographic evaluation of marginal bone levels adjacent to parallel-screw cylinder machined-neck implants and rough-surfaced microthreaded implants using digitized panoramic radiographs

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ABSTRACT

Objective: The purpose of this split-mouth study was to compare macro- and microstructure implant surfaces at the marginal bone level over five years of functional loading.
Materials and methods: From January to February 2006, 133 implants (70 rough-surfaced microthreaded implants and 63 machined-neck implants) were inserted in the mandible of 34 patients with Kennedy Class I residual dentitions and followed until December 2011. Marginal bone level was radiographically determined at six time points: implant placement (baseline), after the healing period, after six months, and at two years, three years, and five years follow-up.
Results: Median follow-up time was 5.2 years (range: 5.1–5.4). The machined-neck group had a mean crestal bone loss of 0.5 mm (0.0–2.3) after the healing period, 1.1 mm (0.0–3.0) at two years follow-up, and 1.4 mm (0.0–2.9) at five years follow-up. The rough-surfaced microthreaded implant group had a mean bone loss of 0.1 mm (−0.4 to 2.0) after the healing period, 0.5 mm (0.0–2.1) at two years follow-up, and 0.7 mm (0.0–2.3) at five years follow-up. The two implant types showed significant differences in marginal bone levels.
Conclusions: Rough-surfaced microthreaded design caused significantly less loss of crestal bone levels under long-term functional loading in the mandible when compared to machined-neck implants.

1. Introduction

In the literature, various aspects of implant micro- and macrostructure effects on marginal bone levels are discussed. Crestal bone changes occur during the early phase of healing after implant placement (Hermann et al., 2000; King et al., 2002, Laine et al., 2005). Typically, there are no significant marginal bone changes during functional loading (Behneke et al., 2002; Engquist et al., 2002). Criteria for successful implant therapy include a median marginal bone loss of 0.5 mm during healing followed by an annual rate of vertical bone loss of less than 0.2 mm per year (Albrektsson et al., 1986; Behneke et al., 2002). Histological investigations show that loading does not affect osteoclast activation in peri-implant bone (Assenza et al., 2003).

These changes are dependent on surface characteristics of the implant, including the presence, absence, and location of an interface (microgap). Crestal bone changes are influenced by potential movement between implants and abutments, but not by the size of the microgap (interface) (Hermann et al., 2001a; Todescan et al., 2002). King et al. (2002) suggested that mobility between components might have an early influence on wound healing surrounding the implant. Furthermore, the biologic width dimensions appear to be more similar to natural teeth around one-piece non-submerged implants compared to either two-piece non-submerged or two-piece submerged implants (Hermann et al., 2001b). Experimental

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and clinical studies demonstrated that implants designed with a shorter, smooth coronal collar caused no additional bone loss and might help reduce the risk of an exposed metal implant margin in areas of aesthetic concern (Alomrani et al., 2005; Hänggi et al., 2005).

A systematic review and meta-analysis show that platform switching may preserve interimplant bone height and soft tissue levels (Atieh et al., 2010). The degree of marginal bone resorption is inversely related to the extent of implant–abutment mismatch (Canullo et al., 2010). Further long-term, well designed, randomized, controlled studies are needed to confirm the validity of this concept (Atieh et al., 2010).

The addition of threads or microthreads up to the crestal module of an implant might provide a potentially positive contribution to bone–implant contact as well as improving preservation of marginal bone (Abuhussein et al., 2010). Shin et al. (2006) concluded that a rough surface with microthreads at the implant neck was the most effective design for minimizing marginal bone loss during functional loading. Abrahamsson and Berglundh (2006) drew similar conclusions in an experimental study in dogs (six beagle dogs with one test and two control implants installed in the mandible). They found that the degree of bone–implant contact within the marginal portion of the implants was significantly higher for the test (microthread) implants (81.8%) compared to control implants (72.8%); this suggests that the microthread configuration offered improved osseointegration.

Radiographic evaluation of marginal bone level around different implant systems showed a positive effect in maintaining marginal bone level for rough surface implants with microthreads at the coronal portion after functional loading (Deppe et al., 2004; Nickenig et al., 2009; Song et al., 2009; Lee et al., 2010). In contrast, Van de Velde et al. (2010) found that after one year of loading a microthread design of the implant collar does not seem to improve bone preservation in the mandible.

A systematic literature review found insufficient data concerning the efficacy of different implant neck configurations in the preservation of marginal bone. The authors concluded that randomized clinical trials are needed to elucidate the effects of modifications like the use of one-piece implants, the concept of platform switching, or the addition of microthreads (Batelli et al., 2011).

Based on these data, we hypothesized that a microstructure on the implant surface could reduce vertical crestal bone resorption. The purpose of this split-mouth study was to compare macro- and microstructures on the implant surface (machined vs. microthreads with rough surface) to determine the effects on marginal bone level under long-term functional loading.

2. Material and methods

2.1. Patient selection

Thirty-four patients with Kennedy Class I residual dentitions in the mandible were referred for implant treatment at a dental clinic (Cologne, Germany) during a two-month period from January to February 2006. Patients were consecutively included in the study according to predefined criteria as follows.

Inclusion criteria:
- Bilateral loss of posterior teeth in the mandible and required fixed restoration.
- Occlusal surfaces in the opposing jaw supported by either natural teeth or implants.
- Presence of adequate bone width on both sides of the mandible, precluding the need for bone augmentation procedures.
- Compliance to control plaque around implants four times a year.Exclusion criteria:
- General medical conditions contraindicating implant surgery.
- Bone volume limited in width, height, or otherwise insufficient for bilateral implant placement in the posterior mandible.
- Missing compliance to plaque control and so indicated professional calculus elimination.
- No history of previous periodontal disease.
- Smoking.

All patients provided informed consent prior to implant placement. All patients got an integer ID number based on the date of their appearance in the clinic. In each patient, one edentulous site of the lower jaw was randomly selected to receive implants with a machined neck; the opposite edentulous site received implants with a rough-surfaced microthreaded neck design. Patients with a pair ID got implants with a machined neck on the right and implants with a rough-surfaced microthreaded neck on the left side of the lower jaw. The inverse procedure was used for patients with an impair ID. The number of implants varied, depending on the number of missing teeth on both sides of the jaw (Kennedy Class I). Follow-up was completed in December 2011.

2.2. Implant therapy

For both groups, the Branemark protocol with a stress-free healing period (three months for the lower jaw) was performed.

The 34 patients were treated with 70 rough-surfaced microthreaded implants (Replace Straight Groovy, Nobel Biocare AB, Gothenburg, Sweden) and 63 machined-neck implants (Replace Select Straight, Nobel Biocare AB, Gothenburg, Sweden). The surgical technique used for fixture placement followed the outline described in the manual for the implant system. All implant sites were prepared for a final diameter of 3.4 mm with final threading. For the first 10 postoperative days, the areas of primary healing were maintained unloaded. After removal of the sutures, existing prostheses were temporarily relined. The implants were located in premolar or molar regions. All implant surgeries were performed by the same dentist.

According to the two-stage technique, fixed partial dentures (FPDs) were placed at three to four months following implant placement. All prostheses were placed by the same dentist, and all laboratory procedures were performed by the same technician. In all cases, gold-machined UCLA-type abutments with a noble alloy (Degunorm, Degussa) for casting were screwed onto the tops of the implants with a torque wrench calibrated at 30 Ncm (Nobel Biocare AB, Gothenburg, Sweden). All restorations were cemented with zinc-phosphate cement (Harvard Cement, Richter & Hoffmann Harvard Dental GmbH, Berlin, Germany).

Accessibility for oral hygiene at the implant sites (with an interdental brush) was given in all restorations.

2.3. Radiographic analysis

Marginal bone level relative to the implant reference point (implant shoulder) was measured mesial and distal to the implants at six time points: implant placement (baseline), after the healing period, after six months of functional loading, and at two, three, and five years follow-up. Using digitized panoramic radiographs, the measurements were performed with the aid of a digital image processing method (Friacom Dental Office Software 2.4, Friatec AG, Mannheim, Germany) (Gomez-Roman et al., 1999, Fig. 1). Marginal bone level was radiographically determined at six time points: implant placement (baseline = T0), after the healing period (T0 until T1), after six months of functional loading (T0 until T2), after two years (T0 until T3), after three years (T0 until T4), and after five years (T0 until T5).