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Clinical Study

Factors Associated with Bone Level Alterations at Implants with Inner-Cone Connection and Platform Switching

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Purpose. This retrospective cohort study evaluated factors for peri-implant bone level changes (ΔIBL) associated with an implant type with inner-cone implant-abutment connection, rough neck surface, and platform switching (AT). *Materials and Methods*. All AT placed at the Department of Prosthodontics of the University of Bern between January 2004 and December 2005 were included in this study. All implants were examined by single radiographs using the parallel technique taken at surgery (T_0) and obtained at least 6 months after surgery (T_1). Possible influencing factors were analysed first using t-test (normal distribution) or the nonparametric Wilcoxon test (not normal distribution), and then a mixed model q variance analysis was performed. *Results*. 43 patients were treated with 109 implants. Five implants in 2 patients failed (survival rate: 95.4%). Mean ΔIBL in group 1 (T_1: 6–12 months after surgery) was -0.65 ± 0.82 mm and -0.69 ± 0.82 mm in group 2 (T_1: >12 months after surgery) ($P = 0.801$). Greater implant insertion depth in diameter 3.5 mm implants might be associated with increased ΔIBL ($P < 0.05$). In the anterior region, the bone alteration was more pronounced ($P < 0.01$). *Conclusions*. ΔIBL values indicated that the implant system used in this study fulfilled implant success criteria.

1. Introduction

Dental implants generally have a high survival rate: on average, only 2.5% of all implants placed are lost before loading. After the incorporation of the reconstruction, the failure rate varies between 0.5% and 1.3% per year [1].

The peri-implant marginal bone level is mainly responsible for the height of the supracrestal soft tissue and thereby for the esthetic success of implant therapy [2]. According to Albrektsson and Isidor [3], a marginal bone loss of ≤1.5 mm during the first year after prosthetic loading and an annual bone loss thereafter not exceeding 0.2 mm were suggested to be consistent with successful treatment. However, the success criteria described above do not reflect the initial part of marginal bone remodeling between surgery and implant loading. Therefore the choice of time point for X-ray baseline will greatly influence the results [4]. Using implant insertion as baseline, peri-implant bone level changes of 0.5–2 mm are expected in the first year [5–8].

On the basis of standard implant design with clearance fit implant-abutment connection, the following factors influencing the amount of peri-implant bone level alteration could be determined: arch, jaw region (anterior region), and smoking status [8]. During the healing phase, immediately placed implants exhibit a slightly pronounced peri-implant bone loss compared with delayed placed implants [9]. Between immediately loaded and delayed loaded implants, no significant differences in peri-implant bone alterations could be detected [10].

Different implant systems yield different results with regard to bone level change [11–13]. A recent meta-analysis reported mean marginal bone level changes of 0.24 mm (Astra Tech Dental Implant System), 0.75 mm (Branemark System), and 0.48 mm (Straumann Dental Implant System) after 5 years of followup, in comparison with levels at the time of prosthetic loading [13]. A possible reason for this difference might be micromovements between abutment and implant [14] or the design of the implant shoulder (retention elements, such as microthreads and a rough neck surface) [15–18].

In studies concerning peri-implant bone level alterations in Astra Tech Dental Implants during the first year, distinctions in bone loss rates could be observed. In this context which time point is defined as baseline for measurement of the peri-implant bone level should be noted. There are values of peri-implant bone level alterations in the literature of 0.02–0.09 mm during the first year [19–21]. However, the baseline of measurements was set at implant loading without regard to the bone loss between implant surgery and implant loading. Thus, depending on the study design, a wide range of peri-implant bone loss rates after a follow-up time of 3 years (0.20–3 mm) exists in the literature [7, 8, 12, 17, 19].

The aim of the present retrospective study was to evaluate factors for marginal bone level alterations associated with an implant type containing an internal conical implant-abutment connection, a rough neck surface design, including microthreads, and platform switching (AT) and to compare the mean peri-implant bone level change with the accepted implant success criteria [3].

2. Materials and Methods

2.1. Data Collection and Implants. In the present retrospective observational/descriptive study [22], all AT (Fixture MT Osseospeed, Astra Tech AB, Mölndal, Sweden) placed at the Department of Prosthodontics of the University of Bern between January 2004 and December 2005 were included. This implant type is designed with an internal conical implant-abutment connection, a rough neck surface, including microthreads, and platform switching. The prosthetic reconstruction of all implants was carried out at the same department. All patients signed an informed consent and the study was performed in compliance with Good Clinical Practice and the Declaration of Helsinki, last revised in Edinburgh in 2000.

2.2. Surgical Procedure. All surgeries were performed under local anesthesia (Ubistesin forte with adrenaline 1 : 100,000; 3 M ESPE, Seefeld, Germany) and premedication with amoxicillin (Clamoxyl), starting 1 h preoperatively (3 × 750 mg). The antibiotic medication was continued in cases using guided bone regeneration (GBR; 3 × 750 mg amoxicillin (Clamoxyl) for 5 days). The patients were instructed to rinse twice daily with 0.12% chlorhexidine (Meridol Perio; GABA, Therwil, Switzerland) for 2 weeks postoperatively, starting the day of surgery. Postsurgical management included suture removal after 7–10 days.

The submerged implants were reentered by elevating a mini full-thickness flap 2-3 months after implant installation. At least 3 weeks later, the implants were loaded. Following prosthetic reconstruction, the patients were seen at least every 9 months for professional plaque control by a dental hygienist and a follow-up appointment by a dentist.

2.3. Radiographic Examination and Evaluation. All implants were examined by means of radiographs taken at surgery (time point 0 (T_0), baseline) and radiographs obtained at least 6 months after implantation (time point 1 (T_1)). The radiographs were single radiographs using the parallel technique (HDX Intraoral X-ray, 65 kV, 7 mA; Dental EZ Group, Lancaster, PA, USA) and analog films (Kodak Ektaspeed Plus; Eastman Kodak Co., Rochester, NY, USA) using film holders. All radiographs were digitalized with a dual-lens system scanner (EPSON PERFECTION V750 PRO, 400 dpi resolution; Seiko Epson Corporation, Nagano, Japan).

The Dimaxis Pro software (ver. 4.3.2; Planmeca, Helsinki, Finland) was used to analyze the radiographs and measurements with a measuring precision of 0.01 mm. The region of interest on the radiographs was magnified using the software tools, and bone height measurements could be calibrated from the implant length.

Marginal bone level was assessed at the mesial and distal aspects of all implants. Only the vertical peri-implant bone level (IBL) was assessed; this was defined as the vertical distance between a reference point at the implant shoulder (Figure 1) and the maximum coronal bone-implant contact. Changes in marginal bone level over time were expressed as differences in the measured values (ΔIBL). The radiographic measurements were independently performed by two calibrated and blinded dentists experienced in oral radiology. Thereafter, the results of measurements were compared: for differences <0.2 mm, the mean of the two measurements was used; for differences >0.2 mm, the two examiners reevaluated the implant together to reach a consensus.

2.4. Statistical Methods. The primary outcome variable was ΔIBL. The following hypotheses were tested:

(i) average ΔIBL values using implant insertion as baseline will be significantly smaller than the limit of >1.1 mm (i.e., 1.5 mm–0.4 mm, whereby 0.4 mm of difference in bone level alterations represents the minimum value for clinical relevance [3, 23]);

(ii) whether the following factors had a significant influence on the degree of ΔIBL:

 (a) age,
 (b) sex,
 (c) immediate implantation,
 (d) diameter of implant,
 (e) length of implant,
 (f) depth of implant insertion,
 (g) kind of suprareconstruction,
 (h) localisation of implant in the jaw,
 (i) time of followup after denture mounting.

The secondary outcome was tested on the following (as a precondition for further tests):

(iii) comparability of mean ΔIBL values on the mesial and distal side of implants.

Table 1: Comparison of bone level alteration of immediate and delayed implants.

Peri-implant bone level alteration	Group 1 (followup between 6 and 12 months)		Group 2 (followup >12 months)	
	Immediate implants ($n = 6$)	Delayed implants ($n = 30$)	Immediate implants ($n = 11$)	Delayed implants ($n = 53$)
Mean	−0.92	−0.59	−0.80	−0.66
Maximum	+1.04	+1.36	−0.13	+1.53
Minimum	−1.72	−2.28	−1.31	−3.63
SD	±1.02	±0.88	±0.37	±0.89
Wilcoxon test	$P = 0.29$		$P = 0.38$	

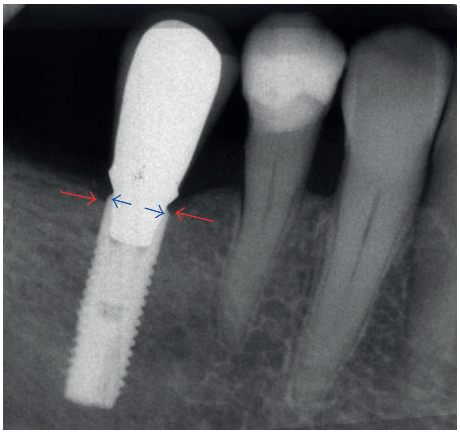

Figure 1: Reference points used in measurements of marginal bone level at the implant (blue arrows) and peri-implant bone (red arrows).

To test (i), an equivalence testing for IBL at T_1 was performed using a t-test and an equivalence range between −0.4 mm and +0.4 mm [23]. To test (ii), first the possible influence factors were analysed separately by means of the t-test (normal distribution) or the nonparametric Wilcoxon test (not normal distribution), and then a mixed model q variance analysis was performed. To test (iii), the Wilcoxon signed rank test was applied. For all statistical analyses, a P value of <0.05 indicated statistical significance.

The RR Development Core Team (2010) and the R-Package nparLD (2009) [24] software packages were used.

2.5. Results. A total of 43 patients (18 females and 25 males) were treated with 109 implants. Five implants in 2 patients failed, all during the healing period, where 1 of the 2 patients lost 4 implants (cluster effect). The corresponding survival rate was 95.4%. Therefore the radiographs of 104 implants in 41 patients (44 implants in females, 60 implants in males) could be evaluated. Fifty-five implants were inserted in the maxilla and 49 implants in the mandibula. The distribution of implant locations and kind of prosthetic reconstruction are shown in Figures 2 and 3. The implant diameter used ranged from 3.5 to 5.0 mm.

No statistically significant difference could be detected in mean ΔIBL value between the mesial (0.68 ± 0.93 mm) and distal (0.68 ± 0.96 mm) aspect of implants ($P = 0.539$). The mean ΔIBL at T_1 was 0.68 ± 0.92 mm (mean follow-up time of 16.0 ± 7.1 months).

The implants were grouped regarding the follow-up time of radiographs between T_0 and T_1: group 1 (T_1: 6–12 months after surgery) and group 2 (T_1: 13–37 months after surgery). Group 1 showed a mean ΔIBL of −0.65 ± 0.82 mm with a mean follow-up time of 9.7 ± 1.5 months and group 2 a mean ΔIBL of −0.69 ± 0.82 mm with a mean follow-up time of 19.5 ± 6.6 months. No statistically significant difference appeared using the t-test between the two groups ($P = 0.801$).

In both groups, overall mean marginal ΔIBL values were significantly lower than the boundary value of –1.1 mm ($P = 0.002$).

Of all factors tested separately, no significant difference in the amount of ΔIBL could be detected. Immediate implants compared with delayed implants showed a slightly pronounced peri-implant bone loss, but the difference was not statistically significant (Table 1).

Using the mixed model q variance analysis, only the interaction between implants with 3.5 mm diameter and implants with 4.0 mm diameter together with the insertion depth had a significant influence on the peri-implant marginal bone level alteration ($P < 0.05$). This means that increased implant insertion depths (i.e., higher peri-implant bone level values at T_0) in implants with 3.5 mm diameter were associated with greater peri-implant marginal bone loss at T_1 compared to implants with ≥4.0 mm diameter (Figure 4). Considering additionally the localisation of implants, a level of significance of $P < 0.01$ was the result: implants with a 3.5 mm diameter in the front region were associated with a greater ΔIBL at T_1 compared to implants with ≥4.0 mm diameter in the posterior region. All other studied parameters showed no influence on ΔIBL.

3. Discussion

The results of the present study demonstrate very limited bone level alteration within the first year after implant surgery. The measured bone loss was clinically significantly (>0.4 mm) smaller than the implant success criterion of 1.5 mm [3], that is, smaller than 1.1 mm ($P = 0.002$). This could raise the question if more strict success criteria regarding marginal ΔIBL should be developed, as the implants tested can provide significantly better results. In this study, baseline was defined as "Implant surgery," which is more strict than the often applied baseline definition "Implant loading":

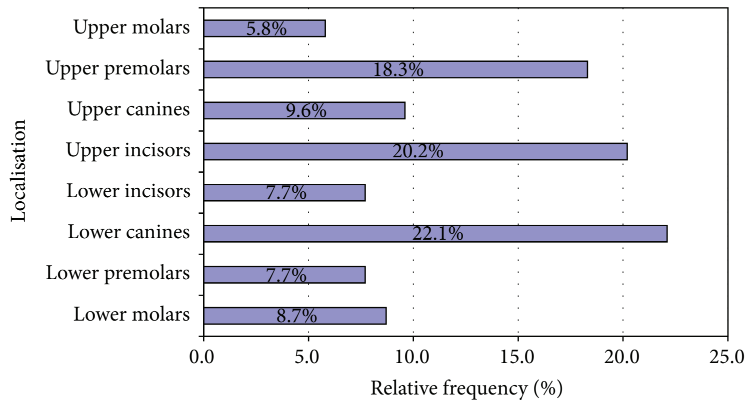

Figure 2: Distribution of implant regarding anatomical regions.

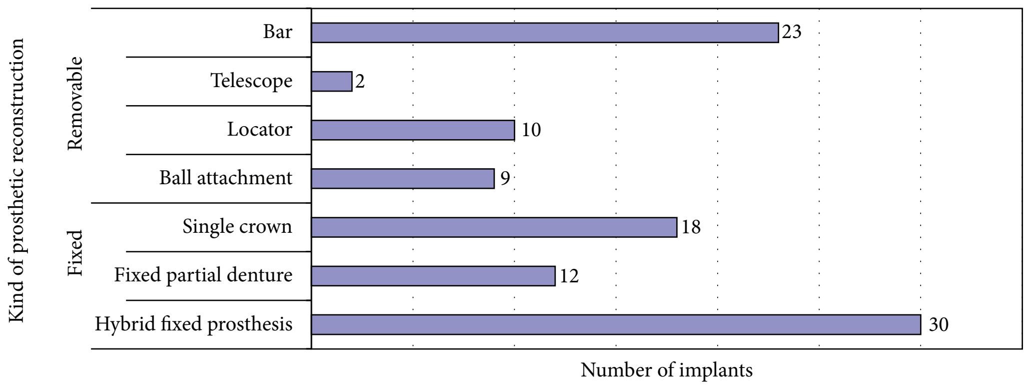

Figure 3: Number of implants regarding kind of prosthetic reconstruction.

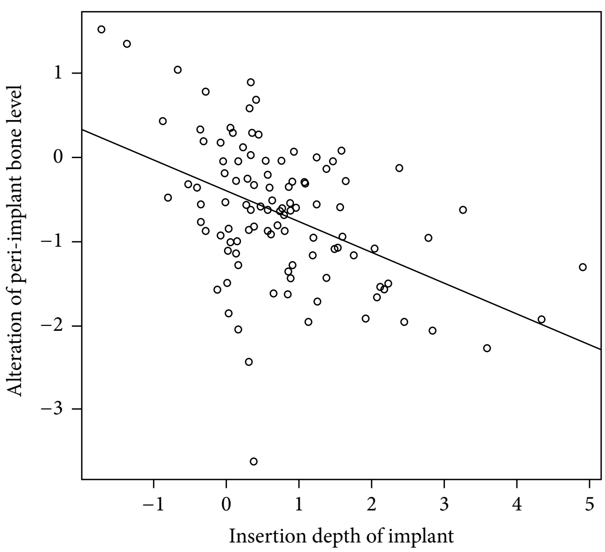

Figure 4: Peri-implant bone level alteration regarding insertion depth of implants at surgery.

in the unloaded healing period between implant surgery and implant loading a distinct bone loss has to be expected and anticipated [12, 25]. Hence, this has to be regarded if these results are compared with published data in which implant loading served as baseline: the measured ΔIBL values (−0.65 ± 0.82 mm in group 1, −0.69 ± 0.82 mm in group 2) were higher than described in other clinical studies [17, 20]. Therefore, the choice of time point to serve as radiographic baseline will greatly influence ΔIBL values [4, 26]. Thus, in future studies, it seems reasonable to choose "Implant surgery" as baseline definition.

In previous studies with standard implant designs, factors associated with a greater ΔIBL were described: smoker habits, edentulous jaw, anterior region in the jaw or maxilla, narrow diameter implants, and immediate implantation [8, 9, 27]. By means of separate testing, astonishingly no statistically significant factor of influence could be detected in the present data. This could be interpreted that the design of the implants tested in this study is superior to the standard implant design. Nevertheless, immediately placed implants compared with delayed placed implants showed slightly higher marginal ΔIBL in the first year after surgery (group 1). Upon expiry of the first year (group 2), in the following years, this small difference seemed to disappear.

Both groups exhibited significant peri-implant bone level changes, and, in accordance with the expectation, no statistically significant difference could be detected between ΔIBL of group 1 (−0.65 ± 0.82 mm) and group 2 (−0.69 ± 0.82 mm). The observation that the greatest peri-implant bone level alteration occurred primarily in the first 6–12 months (i.e., between implant surgery, reopening, impression taking, framework try-in, and loading of the implant) and thereafter only a minimal additional change took place (stable level after the initial remodeling) supports the results of previous clinical trials [10, 11, 25, 28, 29].

Using the mixed model q variance analysis, the presented data demonstrated that the insertion depth was statistically significantly associated with the amount of peri-implant bone loss; that is, the deeper the implant was set, the higher the bone resorption was ($P < 0.05$). A comparable result was observed in animal study using implants with platform switching and inner-cone connection: the amount of bone level alteration was correlated with the implant insertion depth [30, 31]. In the present study, considering the localisation of implants, the effect of bone loss was intensified when the implants were located in the anterior region comparing to the posterior region. A possible explanation might be on one side that implants with reduced diameter are often indicated in situations with reduced horizontal alveolar ridge. As a result, implants were intuitively set deeper (implant shoulder below the bone crest) in order to anticipate postoperative bone resorption.

In this retrospective study, marginal bone levels were measured using single radiographs by means of the parallel technique. Radiographs are a reliable alternative to histologic analysis [32–35].

Different possible reasons might be responsible for the very limited amount of mean peri-implant bone level alteration in the presented data. On one side AT are equipped with bone retention elements (microthreads) and a rough surface at the implant neck. Compared with a smooth machined neck, this neck configuration might help to stabilize the marginal bone level [15]. Clinical trials have demonstrated the preservation of crestal bone contact with implant systems using microthreads [16, 17, 36]. Otherwise, AT posses an internal conical implant-abutment connection. Using the dog model, Hermann et al. [14] (2001) demonstrated that marginal bone loss at implants, where abutments and implants were held together by clearance fit connection (micromovements are possible), was greater than at implants, where the abutments and implants were laser-welded. It was concluded that possible movements between implants and abutments influence the amount of marginal bone changes. Internal conical implant-abutment connections used in AT seem to prevent micromovements under extra-axially applied forces [37]. An in vitro study exhibited that internal conical implant-abutment connections do not prevent endotoxin leakage, but this kind of connection yielded statistically less microleakage at all sampling points than clearance fit connections [38]. This might be a further factor for preservation of peri-implant bone level [39–42].

Additionally, by means of platform switching, the distance from the interface potentially contaminated by endotoxins to the crestal peri-implant bone becomes reduced [43] and the stress level on the crestal bone near the implant might be diminished [44].

AT seems to show only a small amount of initial marginal bone remodeling after surgery; beyond that AT seems to exhibit a decreased sensibility against factors associated with greater marginal bone loss comparing with standard implants. A tendential higher bone loss might be expected by implants with a reduced diameter in the anterior region when they are placed below the bone crest. To substantiate tendencies shown in this study, randomized controlled longitudinal trials are necessary.

Conflict of Interests

The authors declare that they have no conflict of interests. The authors and this research were not sponsored by a company or an organization.

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