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A 10-year prospective study of ITI dental implants placed in the posterior region I: Clinical and radiographic results

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Key words: ITI implants, longitudinal study, non-submerged implants, osseointegration, partial edentulism, peri-implant soft-tissue parameters, posterior mandible, posterior maxilla, radiographic crestal bone loss, smokers

Abstract
Objectives: To evaluate the long-term fixture success rate, crestal bone loss and peri-implant soft tissue parameters around ITI dental implants placed in the posterior region of partially edentulous patients.
Material and methods: A total of 192 ITI dental implants were consecutively placed in premolars and molars of 83 partially edentulous patients admitted for treatment at Geneva Dental School. All implants were restored by means of ceramic-to-metal fused fixed partial dentures and single crowns. Patients were followed as part of a prospective longitudinal study focusing on implant success. Surgical, radiographic and clinical variables were collected at the 1-year recall after implant placement and at the most recent clinical evaluation.
Results: The mean observation time was 6 years (range 5–10 years). Four implants failed, yielding a 10-year cumulative survival rate of 97.9%. The mean annual crestal bone loss was -0.04 ± 0.2 mm. Hollow-cylinder implants displayed more crestal bone loss (-0.13 ± 0.24 mm) than hollow-screw implants (-0.02 ± 0.19 mm; $P = 0.032$). Clinical parameters such as age, gender, implant length and bone quality did not affect crestal bone levels. Increase in recession depth ($P = 0.025$) and attachment level ($P = 0.011$) were significantly associated with crestal bone loss.
Conclusions: ITI dental implants placed in the posterior jaw demonstrate excellent long-term clinical success. Hollow-cylinder implants seem to display a higher risk for crestal bone loss. Recession depth and attachment levels appear to be good clinical indicators of peri-implant bone loss.

Dental implants have been accepted as a viable option for the treatment of fully and partially edentulous patients (Adell et al. 1981; Lekholm et al. 1994; Buser et al. 1997; Weber et al. 2000; Romeo et al. 2004). Early clinical studies on dental implants observed a mean crestal bone loss ranging from 0.9 to 1.6 mm occurring during the first year of function, whereas a mean annual bone loss ranging from 0.05 to 0.13 mm was reported in the follow-up periods (Adell et al. 1981; Lindquist et al. 1988). As a result, a mean annual crestal bone loss (ABL) of less than 0.2 mm was recommended as one of the criteria for implant success (Albrektsson et al. 1986). These observations have also been reported with the ITI dental implant system. Long-term radiographic studies with ITI dental implants demonstrated crestal bone loss ranging from 0.6 to 1.09 mm during the first year and less than 0.2 mm thereafter

Date:
Accepted 6 March 2006

To cite this article:
Blanes RJ, Bernard JP, Blanes ZM, Belser UC. A 10-year prospective study of ITI dental implants placed in the posterior region I: Clinical and radiographic results.
Clin. Oral Impl. Res.
doi: 10.1111/j.1600-0501.2006.01306.x

(Weber et al. 1992; Behneke et al. 1997; Brägger et al. 1998; Mericske-Stern et al. 2001; Karoussis et al. 2004b).

The posterior region of the mouth offers a challenging clinical scenario for rehabilitation with oral implants. The resorption of the alveolar ridge, the presence of the inferior alveolar nerve or the floor of the sinus, poor bone quality and high occlusal forces create a clinical environment that may jeopardize the long-term biological and biomechanical success of the implant restoration. Radiographic information on crestal bone-level (CBLE) changes around implants placed in the posterior regions is limited. Long-term reports of ITI dental implants have demonstrated that the ABL rate around implants placed in the posterior region is less than 0.1 mm (Brägger 1998; Weber et al. 2000; Mericske-Stern et al. 2001; Romeo et al. 2004). However, despite this clinical and radiographic implant success, a group of dental implant restorations appeared to experience ABL >0.2 mm (Weber et al. 1992; Brägger 1998; Carlsson et al. 2000; Mericske-Stern et al. 2001; Karoussis et al. 2004b). This loss has been associated with various factors, such as gender (Ahlquist et al. 1990), surgical trauma (Lekholm et al. 1986), plaque accumulation (Lindquist et al. 1988, 1996; Wennstrom et al. 2004), smoking (Lindquist et al. 1996; Hultin et al. 2000; Bain et al. 2002), biological width (Hermann et al. 1997), bone quality (Adell et al. 1981; Ahlquist et al. 1990), implant design (Buser et al. 1997; Karoussis et al. 2004b) and biomechanical factors (Lindquist et al. 1988; Isidor 1997; Brunski 1999; Wood & Vermilyea 2004).

Several periodontal clinical parameters have been proposed as diagnostic markers to evaluate implant success. Modified plaque and bleeding indices may be used to evaluate oral hygiene as well as the amount of peri-implant soft-tissue inflammation. Peri-implant probing depth may also be a valuable diagnostic tool for detecting inflammation and infection around dental implants (Albrektsson & Isidor 1994; Karoussis et al. 2004a); however, it appears to be of little value in detecting CBLE changes (Weber et al. 2000). In addition to these clinical parameters, implant mobility has also been considered a useful marker in the diagnosis of implant failure. The Periotest value (PTV; Siemens, Bensheim, Germany) allows the assessment of low degrees of implant mobility and thus of the osseointegration status of the implant restoration (Olive & Aparicio 1990; Teerlinck et al. 1991).

The purpose of this study was three-fold. First, to evaluate the long-term fixture survival and success rates of ITI dental implants placed in the posterior region of partially edentulous patients. Second, to report CBLE changes around these implants and to find any association with various clinical factors collected during the study. Third, and finally, to report changes in peri-implant soft tissue parameters and mobility patterns around dental implants in order to evaluate their value as indicators for peri-implant crestal bone loss.

Material and methods

Patient enrollment

Since April 1989, the Geneva Dental School has been treating patients with the ITI implant system following a strict protocol of documentation, that includes surgical, periodontal and prosthetic variables. All implants placed were part of a prospective clinical study on non-submerged ITI implants (Institute Straumann AG, Waldenburg, Switzerland). For the purpose of this study, patients were selected according to the following inclusion criteria:

(1) Implants placed from October 1989 to January 1994. As a result, all implants demonstrated at least 5 years of follow-up.
(2) Partially edentulous patients.
(3) Implants placed in the maxillary and mandibular premolar and molar regions.
(4) Implant designs: standard hollow cylinder, standard hollow screw, standard solid screw and narrow solid screw.
(5) Implants restored by means of a fixed partial denture or a single crown. The provisional phase of the restoration did not exceed the second year of follow-up after implant placement.

Provisional restorations are understood as full-acrylic restorations. During this study period, 247 ITI dental implants were placed consecutively in the premolar and molar areas of 109 patients. The patient drop-out rate was 19.2% (21 patients), which accounted for 17.8% (44 implants) of the implants. In addition, although radiographic evaluation showed favorable results, two patients (three implants) were not included in the radiographic analysis due to the inability to observe clearly visible threads, while in three patients (eight implants) proper measurements were not possible because radiographic examination was performed with panoramic films. The final sample included 192 implants placed in 83 patients. The mean age of the patients was 60.6 years (range 32.6–80.2 years). The study group included 119 (62%) implants placed in women and 73 (38%) implants placed in men. A total of 14 patients were smokers (16.8%): five of them were mild smokers (<10 cigarettes a day), whereas nine were considered heavy smokers (>10 cigarettes a day).

Surgical procedures and variables

All implants were inserted by one surgeon following the same protocol (Buser et al. 1990). A 3–6-month healing period was allowed before prosthetic loading. During the surgical intervention, the following variables were collected:

Implant type: 153 (79.7%) dental implants were hollow-screw, 26 (13.5%) were hollow-cylinder, nine (4.7%) were solid screw and four (2.1%) were reduced-diameter screw implants.

Implant length: Nearly half of the implants inserted were 6 and 8 mm (43.8%).

Implant location: 139 implants (72.4%) were placed in the mandible and 53 (27.6%) were placed in the maxilla. Eighty-eight implants (45.8%) replaced a premolar unit, while 104 (54.2%) replaced a molar unit.

Bone density: Patients were divided into three groups as determined by the operator: a group with very dense bone (type I), corresponding to type-I bone after Lekholm & Zarb 1985; a second group (type II) with cortical and spongy bone (types II and III; Lekholm & Zarb 1985); and a third group (type III) with very spongy bone (type IV; Lekholm & Zarb 1985). Forty-one (21.4%) of the recipient sites displayed type-I bone quality, 118 (61.5%) showed type-II quality and only 33 (17.2%) showed type-III bone quality.

Radiographic peri-implant bone loss analysis

Radiographic analysis was performed on standardized periapical radiographs taken by an experienced radiologist 1 year after implant placement and every 2 years, thereafter, using the long-cone paralleling technique and the Rynn system (XCP Instruments, Rinn Corporation Elgin, IL, USA). Effort was aimed at attaining clearly visible threads. No further attempts were used for standardization. Radiographs were mounted on slides and projected on the screen with a magnification factor of $\times$ 13. From the series of periapical radiographs taken during the longitudinal evaluation, the first-year and the most recent radiographs were selected. The landmarks were taken twice, 1 week apart, by two examiners reaching consensus (Brägger et al. 1998). The following *linear measurements* between landmarks were taken (Fig. 1): (1) AIL: anatomical implant length (perpendicular distance from the implant shoulder to the most apical aspect of the implant); and (2) CBLE (perpendicular distance from the implant shoulder to the first visible apical bone-to-implant contact in the mesial and distal aspects of the implant). Real measurements were calculated with the rule of three using the real implant length or the distance between threads as the reference values. The following *radiographic variables* were calculated: (1) ACBLE: average mesio-distal CBLE; (2) TCBL: total crestal bone loss (initial ACBLE–final ACBLE); and (3) ABL (TCBL/months of follow-up $\times$ 12). The precision of the radiographic measurements was calculated by comparing the values of the first and second radiographic readings (Table 1). Correlations for the first and second measurements of CBLE and AIL were $r = 0.93$ and 1, respectively (Pearson's correlation test).

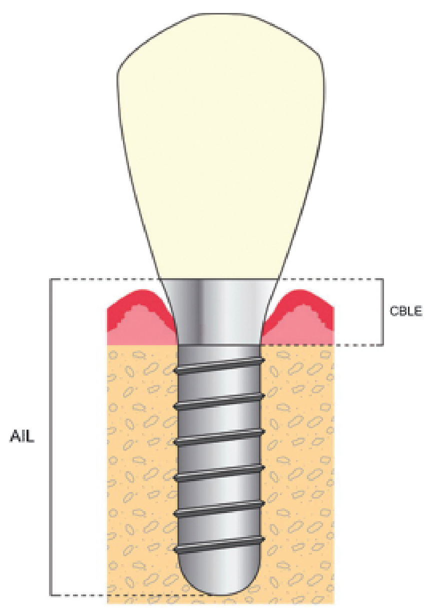

Fig. 1. Periimplant radiographic measurements: (1) AIL, anatomical implant length; (2) CBLE, crestal bone level.

***Table 1.* Comparison between the first and second radiographic measurements of peri-implant crestal bone level (CBLE) and anatomical implant length (AIL)**

	Comparison between first and second readings
CBLE	
Readings performed	1536
Mean difference	0.02 mm
Minimum difference	−2.2 mm
Maximum difference	1.62 mm
Differences within ± 0.25 mm	52.3%
Differences within ± 0.5 mm	82.5%
Differences within ± 1 mm	96.4%
Correlation between first and second readings*	0.93
AIL	
Readings performed	768
Mean difference	0 mm
Minimum difference	−0.58 mm
Maximum difference	0.46 mm
Differences within ± 0.25 mm	100%
Differences within ± 0.5 mm	–
Differences within ± 1 mm	–
Correlation between first and second readings*	1

*Pearson's correlation analysis.

Clinical variables

The following clinical variables were collected at 3, 6 and 12 months after implant placement and every 2 years thereafter by the hygienist in the Oral Surgery department (Fig 2): (1) implant failure: implant failure criteria were defined as described previously (Buser et al. 1990); (2) loading time; (3) PPI: peri-implant plaque index (Mombelli et al. 1987); (4) PSBI: peri-implant sulcus bleeding index (Mombelli et al. 1987); (5) PPD: peri-implant probing pocket depth: measured to the nearest millimeter with a Hu-Friedy PGF–GFS periodontal probe (Hu-Friedy, Chicago, IL, USA); (6) DIM: distance from the implant shoulder to the gingival margin was recorded to the nearest millimeter. In the presence of a subgingival implant shoulder, the measurement was recorded as a negative value; (7) PAL: peri-implant attachment level: calculated for each site by adding probing depth and recession depth and (8) PTVs: The Periotest (Siemens, Bensheim, Germany) method was utilized as previously described (Schulte 1986). PTVs were measured at the implant–crown junction.

Statistical analysis

Descriptive analysis – consisted of mean and standard deviation for all variables and each group.

Comparative analysis – Crestal bone loss was analyzed in patients grouped according to age, gender, implant type, implant length, implant location, bone density and smoking status. When the means of two groups were compared, a parametric unpaired *t*-test was utilized. However, if three groups were compared, the one-way parametric analysis of variance test (ANOVA) was applied. If the groups were heterogeneous (Bartlett's test), Wilcoxon's test was used for comparisons between two groups and the Kruskal–Wallis test was used for comparisons among three groups. Unconditional logistic regression analysis was conducted to evaluate the risk of crestal bone loss among different implant designs and implant locations. For peri-implant soft tissue parameters, the sample was divided into implants that gained and lost bone. The change in these parameters from the initial to the final examination was calculated for each group. *P*-values of less than 0.05, were considered statistically significant and thus clinically meaningful.

Results

Implant survival

Out of 192 fixtures, failure occurred in four implants (four patients), giving a cumulative survival rate of 97.9%. All failures were caused by the presence of a peri-implant infection. No failures occurred during the osseointegration phase.

Peri-implant bone loss analysis

The mean initial CBLE at the first-year evaluation was 3.96 ± 0.99 mm. The mean final CBLE at the most recent examination was 4.24 ± 1.25 mm. The mean TCBL was − 0.24 ± 1.16 mm, while the mean ABL was − 0.04 ± 0.2 mm (Table 2; Fig. 3a and b). About 32 (16.7%) of the implants lost more than 0.2 mm annually, while 76 (39.5%) lost between 0.01 and 0.19 mm. Overall, 56.2% of the implants lost bone, while 43.8% experienced some bone gain (Fig. 4a and b).

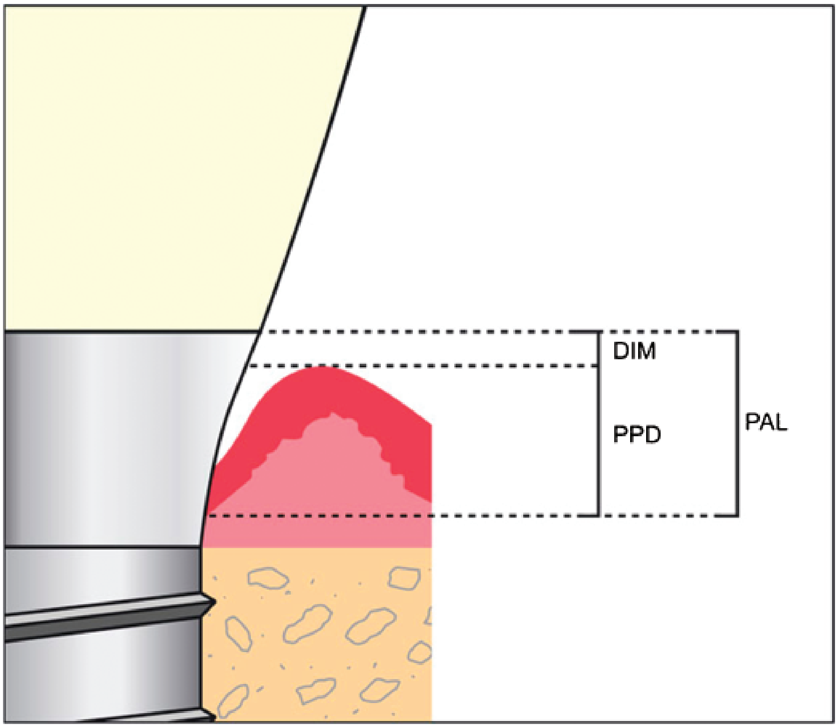

Fig. 2. Periimplant soft-tissue measurements: (1) PPD, periimplant probing depth ; (2) DIM, distance implant-gingival margin; (3) PAL, periimplant attachment level.

***Table 2.* Mean peri-implant crestal bone level (CBLE) and annual crestal bone loss (ABL)**

	Mesial (mm)	Distal (mm)	Mean (mm)
First year CBLE	3.89 ± 0.98	4.05 ± 1.1	3.96 ± 0.99
Final year CBLE	4.18 ± 1.47	4.29 ± 1.28	4.24 ± 1.25
TCBL	− 0.24 ± 1.55	− 0.24 ± 1.58	− 0.24 ± 1.16
ABL	–	–	− 0.04 ± 0.2

TCBL, total crestal bone loss.

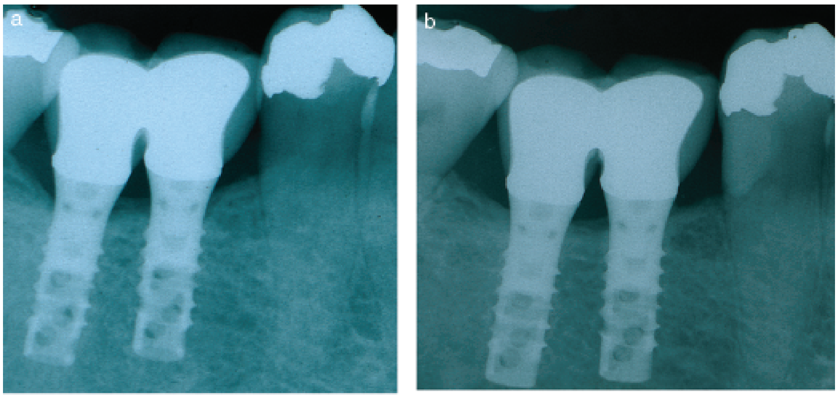

Fig. 3. (a) Radiographic peri-implant crestal bone level around a dental implant-supported restoration at the 1-year evaluation. (b) Radiographic evidence of periimplant crestal bone stability around the same dental implant-supported restoration at the 6-year evaluation.

Clinical variables

PPI: Patients in this study maintained excellent oral hygiene. In the initial examination, 87% of the implants sites displayed no plaque accumulation. In the final exam, the number of plaque-free sites remained high and even showed a slight increase. The change in plaque accumulation between the initial exam and the final exam for the mesial, lingual and buccal sites was not statistically significant (Wilcoxon's test: mesial, $P = 0.052$; buccal, $P = 0.127$; lingual $P = 1$). However, distal sites increased significantly (Wilcoxon's test: $P = 0.002$).

PSBI: In the initial examination, 87% of the implants sites showed healthy gingiva, with no signs of gingivitis. Similar findings were seen in the final examination. The change in bleeding tendency between the initial and the final exam for the mesial, distal, lingual and buccal sites was not statistically significant (Wilcoxon's test: mesial, $P = 0.194$; buccal, $P = 0.251$; distal, $P = 0.258$; lingual $P = 0.899$).

PPD: The average initial and final probing depths were 2.7 ± 0.54 and 2.54 ± 0.46 mm, respectively. There was a statistically significant decrease in probing depth (paired *t*-test: $P = 0.001$).

PAL: The average initial and final attachment levels were 2.86 ± 0.77 and 2.86 ± 0.81 mm, respectively (paired *t*-test: $P = 0.897$).

DIM: The average initial and final recession depths were 0.15 ± 0.54 and 0.33 ± 0.7 mm, respectively. The difference between the values reached significance (paired *t*-test: $P = 0.001$).

PTVs: The average initial and final PTV were − 2.45 ± 2.97 and − 3.24 ± 3.15 mm, respectively. This decrease in

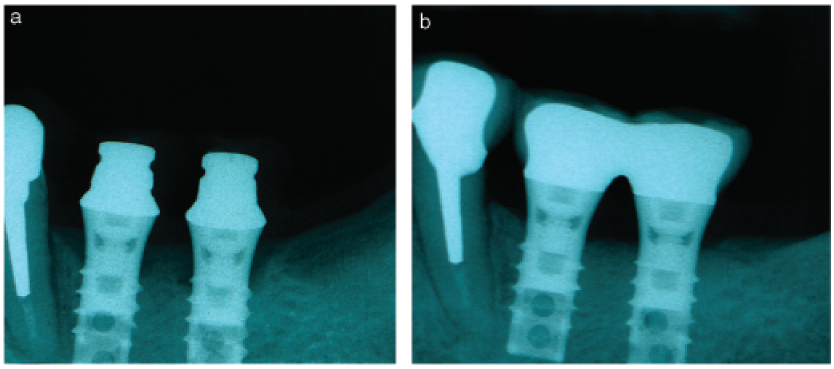

Fig. 4. (a) Radiographic evidence of peri-implant crestal bone loss after 1 year of implant placement. (b) Notice the crestal bone gain around the same implant-supported restoration after 7 years.

Table 3. **Annual crestal bone loss (ABL) with respect to implant type**

Implant type	Number of implants	ABL (mm)
Hollow screw	151	-0.02 ± 0.19
Hollow cylinder	26	-0.13 ± 0.24*
Solid screw standard	9	-0.14 ± 0.17
Solid-screw narrow	4	-0.04 ± 0.12

*ABL around hollow-cylinder > ABL around hollow-screw. Tukey's test; $P=0.032$.

Table 4. **Logistic regression analysis of annual crestal bone loss (ABL) with regard to implant location and implant type**

Groups	Odds ratio	95% confidence bounds	
Implant location			
Maxillary Premolar location*	1		
Mandibular premolar location	0.3447†	0.1303	0.9119
Maxillary molar location	0.3535	0.9276E-01	1.347
Mandibular molar location	0.7256	0.295	1.784
Implant type			
Hollow screw*	1		
Hollow cylinder	2.686	0.9936	7.259
Solid-screw standard	2.997	0.5278	17.02
Solid-screw narrow	3.964	0.3729	42.14

*Group of reference.
†The mandibular premolar location showed three times lesser risk for bone loss than the maxillary premolar location.

PTVs over time was statistically significant (paired t-test: $P=0.002$).

Clinical correlation

Gender: Women (-0.04 ± 0.21 mm.) and men (-0.04 ± 1.91 mm) showed similar annual bone loss rates (ANOVA test; $P=0.891$).

Age: Annual bone loss in patients ≥ 60 years old was -0.02 ± 0.19 mm, while annual bone loss in patients <60 was -0.06 ± 0.2 mm (ANOVA test: $P=0.116$).

Implant type: Annual bone loss around hollow-screw, hollow-cylinder, solid-screw and solid-screw narrow implants was -0.02 ± 0.19, -0.13 ± 0.24, -0.14 ± 0.17 and -0.04 ± 0.12 mm, respectively. Statistical analysis revealed significantly greater bone loss around the hollow-cylinder design as compared with the hollow-screw implant (Tukey's test; $P=0.032$; Table 3). Logistic regression analysis demonstrated higher risk for bone loss around the hollow-cylinder design; however, this tendency did not reach statistical significance (Table 4).

Implant length: Fixtures of 6–8 mm showed a loss of -0.05 ± 0.18 mm of crestal bone, while fixtures of 10–12 mm displayed a loss of -0.03 ± 0.21 mm (ANOVA test ; $P=0.526$).

Implant location: The maxillary premolar area experienced more crestal bone loss than any other location. This difference was statistically significant (Kruskal–Wallis test; $P=0.004$). Logistic regression demonstrated that the premolar location showed three times more risk of bone loss than the mandibular premolar area (Table 4). Maxillary implants showed a tendency toward greater bone loss (-0.08 ± 0.24 mm) than mandibular implants (-0.02 ± 0.18 mm). This trend almost reached statistical significance (Kruskal–Wallis test; $P=0.062$). Molar (-0.04 ± 0.16 mm) and premolar (-0.04 ± 0.24 mm) locations showed similar bone loss (Kruskal–Wallis test; $P=0.89$).

Bone density: Fixtures placed in type-I bone experienced more bone resorption than fixtures placed in type-III bone; however, the difference was not statistically significant (ANOVA test; $P=0.153$).

Smoking: Smokers showed a trend toward greater bone loss (-0.09 ± 0.27 mm) than non-smokers (-0.03 ± 0.18 mm). However, statistical analysis did not reveal any significance (Kruskal–Wallis test; $P=0.454$).

*Peri-implant soft tissue parameters (*Table 5*): PPD*: the change in probing depth around implants that gained bone was -0.23 ± 0.6 mm, while in implants that lost bone the value was -0.12 ± 0.73 mm. The difference between groups was not significant (ANOVA test; $P=0.256$). *PAL*: the change in PAL was 0.16 ± 1.08 mm in implants that lost bone and -0.18 ± 0.8 mm in implants that gained bone. The statistical analysis revealed significance (Kruskal–Wallis test; $P=0.011$). *DIM*: implants that lost bone displayed a change in recession depth of 0.27 ± 0.7 mm, while the change in implants that gained bone was 0.06 ± 0.57 mm. The ANOVA test displayed a statistical difference between groups ($P=0.025$). *PTVs* (Table 5): The change in PTVs of implants that lost bone was -0.61 ± 3.38 mm, while this value was -1.02 ± 3.45 mm in implants that gained bone (ANOVA test; $P=0.406$).

Discussion

In this study, ITI dental implants showed excellent long-term survival and success rates in the posterior jaw. These data seem to agree with the results of other authors evaluating the long-term perfor-

Table 5. **Crestal bone level change with respect to peri-implant soft tissue parameters and PTVs values**

Bone-level change	Number of implants	ΔPeri-implant probing depth (mm)
≥ 0 (gain of bone)	84	−0.23 ± 0.6
<0 (loss of bone)	108	−0.12 ± 0.73

Bone-level change	Number of implants	ΔPeri-implant attachment level (mm)
≥ 0 (gain of bone)	84	−0.18 ± 0.8*
<0 (loss of bone)	108	0.16 ± 1.08

Bone-level change	Number of implants	ΔPeri-implant recession depth (mm)
≥ 0 (gain of bone)	84	0.06 ± 0.57†
<0 (loss of bone)	108	0.27 ± 0.7

Bone level change	Number of implants	ΔPTVs
≥ 0 (gain of bone)	84	−1.02 ± 3.45
<0 (loss of bone)	108	−0.61 ± 3.38

Groups were divided according to implants that gained and lost bone.
*Kruskal–Wallis test; $P = 0.011$.
†ANOVA test $P = 0.025$.
PTV, Periotest value.

mance of ITI dental implants (Weber et al. 1992, 2000; Behneke et al. 1997; Mericske-Stern et al. 2001; Astrand et al. 2004; Nedir et al. 2004; Romeo et al. 2004).

The mean ABL around ITI dental implants in this study was −0.04 mm. In our study, 16.7% of the implants experienced bone loss above the threshold representing stable bone levels. Several reports on different implant systems demonstrate that, despite excellent average crestal bone loss, approximately 20% of the sample experienced bone loss above this rate (Weber et al. 1992; Brägger 1998; Carlsson et al. 2000; Karoussis et al. 2004b). Interestingly, in these studies and in ours, the mean ABL rate was lower than the proposed threshold acceptable for long-term implant success: ≤0.2 mm (Albrektsson et al. 1986). Nevertheless, 20% of the implants did not reach this threshold. It would be more realistic to report the data on implant success according to the number of implants experiencing bone loss above and below the acceptable bone loss threshold, rather than presenting crestal bone loss as a mean value, which could overestimate the success of implants in the study. Based on this observation, the criteria for long-term success of dental implants should be redefined.

Some of the implants in this study (43.8%) showed crestal bone gain around the fixtures during the evaluation period. This bone response has been reported in several longitudinal clinical studies on dental implants (Adell et al. 1981; Quirynen et al. 1992a; Weber et al. 1992) and has been attributed to the stimulating capacity of the loaded fixtures on the remodeling of the perifixtural bone (Brunski 1999).

The methodology utilized for the radiographic assessment of crestal bone loss in this study is similar to the technique used by other authors who reported a very low measurement error: 0–0.03 mm (Brägger et al. 1998). Further standardization with the use of bite impressions was not possible due to the inherent difficulties of this approach in a long-term evaluation of dental implants. However, our measurement error of CBLE (0.02 mm) compares favorably with other studies using special holding devices (Eggen 1976; Hollender & Rockler 1980; Adell et al. 1981; Brägger et al. 1998).

The hollow-cylinder and the solid-screw implants showed greater bone loss than the other implant designs; however, only the hollow-cylinder implant reached statistical significance. This finding confirms not only *in vitro* observations showing less bone stress around the entire periphery of the threaded implants compared with non-threaded implants surfaces (French et al. 1989; Deines et al. 1993) but also confirms previous long-term results for ITI dental implants (Buser et al. 1997; Karoussis et al. 2004b).

Several studies have noted that peri-implant probing is a good indicator of crestal bone loss (Quirynen et al. 1992b; Brägger et al. 1996; Karoussis et al. 2004a). Our data seem to agree with these observations. Attachment level and recession depth were correlated with crestal bone loss, whereas probing depth and PTVs were not. Implants with crestal bone loss displayed increasing attachment levels and increasing recession depth over time, while implants with crestal bone gain showed the contrary. Contradictory findings have been presented by other authors, who found a lack of correlation between crestal bone loss and peri-implant soft tissue parameters (Weber et al. 2000). Study design differences could explain the controversial findings. First, in the Weber study, dental implants were only followed for 5 years. And second, crestal bone loss was evaluated with panoramic radiographs, which has been found to be less precise in the assessment of crestal bone loss (Penarrocha et al. 2004).

PTVs have been utilized to evaluate the damping characteristics around dental implants. Although some authors have suggested that the Periotest is useful for providing information on the early osseointegration status of implants (Olive & Aparicio 1990; Teerlinck et al. 1991), its value as a monitoring and prognostic test for implant outcome is under discussion. We noted that PTVs did not correlate with crestal bone loss over time, confirming the lack of validity of this parameter as a predictor for crestal bone loss. This observation has also been reported in other studies (Brägger et al. 1996).

Smoking has been shown to have a deleterious effect on both osseointegration and maintenance of crestal bone (Lindquist et al. 1996; Hultin et al. 2000; Bain et al. 2002; Oates et al. 2004; Nitzan et al. 2005). Our results indicate that smokers show a greater tendency to lose crestal bone, although this trend did not reach statistical significance. These results should be interpreted with caution, as only 16.8% of the implants included in the study were placed in smokers.

This study indicates that the upper premolar location is associated with crestal bone loss. This finding could be attributed to the occlusal prematurities normally present on the bicuspids (Shefter & McFall 1984). These premature contacts may act as a form of occlusal overload, which has been correlated with peri-implant crestal bone loss (Hoshaw et al. 1994; Isidor 1997). Accordingly, the observations made in our study confirm the need for periodical occlusal controls as part of the implant maintenance protocol.

In summary, the findings of this prospective study indicate that ITI dental implants placed in the posterior jaw show excellent long-term clinical success and acceptable crestal bone loss rates. Hollow-cylinder implants displayed greater bone loss than hollow-screw implants. Consequently, the use of the former should be contraindicated in the posterior region of the mouth. Peri-implant soft tissue parameters such as recession depth and attachment level were significantly associated with CBLEs and therefore seem to be good clinical predictors of bone loss around ITI dental implants.

Acknowledgement: We thank Dr Ildefonso Hernandez for his statistical support in the analysis of the data. The assistance of Mrs Alexandra Giacinti in data collection is also greatly appreciated.

要旨
目的：部分無歯顎患者の臼歯部に埋入したITIインプラントに関して、フィクスチャーの長期成功率、骨頂の喪失およびインプラント周囲軟組織の諸パラメータを評価する事。
方法と材料：ジュネーブ歯科大学に来院した部分無歯顎患者８３名の小臼歯、大臼歯部に合計１９２本のITIインプラントを連続埋入した。インプラントは全て金属焼付け陶材の固定式部分義歯と単冠によって修復した。患者は前向き、経時的研究の一環として、インプラントの成功率に焦点をあてた経過観察を受けた。術式、レントゲン像および臨床上の変数を、インプラント埋入一年後のリコール時と最も直近の臨床診査時に収集した。
結論：平均観察期間は6年（5年から10年の領域）であった。インプラント4本が失われ、10年間の累積存続率は97.9%となった。平均年率骨頂喪失量は-0.04±0.20mmであった。中空シリンダー型インプラント（-0.13±0.24mm）は中空スクリュー型インプラント（-0.02±0.19mm）よりも骨頂の喪失量が多かった（P=0.032）。年齢、性別、インプラントの長さ、骨質などの臨床的パラメータは骨頂レベルに影響を及ぼさなかった。退縮深度の増加（P=0.025）と付着レベル（P=0.011）は骨頂の喪失と有意に相関していた。
結果：臼歯部に埋入したITI歯科インプラントは優れた長期の臨床的成功を示した。中空シリンダー型インプラントは骨頂喪失のリスクが高いと思われる。退縮深度と付着レベルはインプラント周囲の骨喪失のよい臨床的な指標になると思われる。

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