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Two-stage IMZ implants and ITI implants inserted in a single-stage procedure

A prospective comparative study

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Abstract: The aim of this study was to evaluate the feasibility of using a two-stage implant system in a single-stage procedure and to study the impact of the microgap at crestal level and to monitor the microflora in the peri-implant area. Forty edentulous patients (Cawood & Howell class V–VI) participated in this study. After randomisation, 20 patients received two IMZ implants inserted in a single-stage procedure and 20 patients received two ITI implants. After 3 months, overdentures were fabricated, supported by a bar and clip attachment. A standardised clinical and radiographic evaluation was performed immediately after denture insertion and 6 and 12 months later. Twelve months after loading, peri-implant samples were collected with sterile paper points and analysed for the presence of putative periodontal pathogens using culture techniques. One IMZ implant was lost due to insufficient osseointegration. With regard to the clinical parameters at the 12 months evaluation, significant differences for plaque score and probing pocket depth (IMZ: mean 3.3 mm, ITI: mean 2.9 mm) were found between the two groups. The mean bone loss in the first year of functioning was 0.6 mm for both groups. *Prevotella intermedia* was detected more often in the ITI group (12 implants) than in the IMZ group (three implants). *Porphyromonas gingivalis* was found in three patients. In one of these patients an implant showed bone loss of 1.6 mm between T0 and T12. Some associations were found between clinical parameters and the target microorganisms in the ITI group. These associations were not present in the IMZ group. The short-term results indicate that two-stage implants inserted in a single-stage procedure may be as predictable as one-stage implants. The microgap at crestal level in nonsubmerged IMZ implants seems to have no adverse influence on the peri-implant microbiological colonisation and of crestal bone loss in the first year of functioning. The peri-implant sulcus can and does harbour potential periodontal pathogens without signs of peri-implantitis during the evaluation period of 1 year.

Many different endosseous implant systems are currently used in oral implantology. Most implant systems consist of two parts, i.e. the implant, which is submerged during a first surgical procedure, and the transmucosal abutment, which is connected to the implant during a second surgical procedure. For this reason, these implant systems are collectively referred to as 'two-stage' systems. 'One-stage' implant systems consist of one part, which is inserted during a single surgical procedure. Well-documented long-term clinical studies have revealed that both system types have highly predictable outcomes (Adell et al. 1990; Lindquist et al. 1996; Haas et al. 1996; Heydenrijk et al. 1998; Buser et al. 1999).

Insertion of implants in one stage has several advantages (Buser et al. 1999):

1. only one surgical intervention is required, which is much more convenient for the patient, especially for the medically compromised patient;
2. there is a cost-benefit advantage;
3. there is a time-benefit since the prosthetic phase can start earlier because there is no wound healing period involved related to a second surgical procedure;
4. during the osseointegration period, the implants are accessible for clinical monitoring.

However, one-stage implants are not the preferred treatment (Røynesdal et al. 1999):

1. in combination with an augmentation procedure or guided bone regeneration when the wound has to be closed tightly to prevent infection and bone or membrane exposure;
2. if the integrated abutment interferes with a functional or esthetical design of the suprastructure;
3. to prevent undesirable loading of the implants during the osseointegration period when the temporary suprastructure can not be adjusted effectively.

In several recent studies, applying two-stage implants in a single surgical procedure has been reported to be promising (Bernard et al. 1995; Ericsson et al. 1994, 1996, 1997; Becker et al. 1997; Collaert & De Bruin 1998; Abrahamsson et al. 1999; Røynesdal et al. 1999; Fiorellini et al. 1999). The reported clinical and radiological outcomes suggest that the frequently cited rationale for using a two-stage approach, i.e. to minimise the risk of infection and to prevent apical down growth of mucosal epithelium, is at least questionable.

Since one-stage implant systems and two-stage implant systems inserted in a single-stage procedure seem to have comparable results, there are some advantages to using the latter method:

1. the surgeon only needs to have a two-stage implant system in stock for executing both submerged and nonsubmerged procedures;
2. it is possible to switch from a nonsubmerged procedure to a submerged procedure during the operation when this appears to be preferable;
3. during the osseointegration period, the healing abutment can be removed if the temporary prosthesis cannot be adjusted in such a way that the implant will not be loaded;
4. the coronal part of the implant is located at the crestal level, giving the possibility for a more flexible emergence profile of the transmucosal part.

It has been proposed that marginal bone loss is more extended around two-stage implants than around one-stage implants (Buser et al. 1999). The microgap between the implant and the abutment at the crestal level has been suggested to play a prominent role in the development of this bone loss (Hermann et al. 1997). However, when measured on standardised intraoral radiographs, marginal bone loss has been observed around one-stage ITI implants as well (Weber et al. 1992; Batenburg et al. 1998a). In animal studies, comparable marginal bone levels were found around one-stage and two-stage implant systems (Abrahamsson et al. 1996; Fiorellini et al. 1999). Thus, the suggestion that the microgap is entirely responsible for marginal bone loss is questionable.

It has been suggested that bacterial infection can result in peri-implant bone loss or loss of implants (Rosenberg et al. 1991; Leonhardt et al. 1999; Van Winkelhoff & Wolf 2000). Possibly, the microflora colonising the microgap or their products is responsible for the occurrence of this bone loss (Lindhe et al. 1992; Quirynen & van Steenberghe 1993, Ericsson et al. 1995; Persson et al. 1996;). Putative periodontal pathogens have been implicated in the onset and progression of peri-implantitis (Ellen 1998). However, it remains unclear whether these pathogens constitute a risk factor for the maintenance of dental implants (Danser et al. 1997). Nevertheless, periodontal pathogens such as *Porphyromonas gingivalis* and *Actinobacillus actinomycetemcomitans* can cause peri-implant infections, especially in partially edentulous patients with a history of periodontitis (Van Winkelhoff et al. 2000; Van Winkelhoff & Wolf 2000). The prevalence of peri-implant infection in patients carrying these pathogens is, however, unknown.

No studies have been published comparing a one-stage implant system with two-stage implants inserted in a single-stage procedure. The aim of the present study was to compare peri-implant radiographic bone loss, clinical parameters and microbial colonisation following the insertion of nonsubmerged two-stage implants and one-stage implants in order to explore the feasibility of inserting two-stage implants in a nonsubmerged procedure. Moreover, the impact of the microgap and of the colonisation of the peri-implant area by putative periodontal pathogens was evaluated.

Material and methods

Patient selection

Forty edentulous patients, 25 women and 15 men, with a mean age of 58 years (SD = 10 years), referred to the Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthetics of the University Hospital Groningen, were selected on the basis of the following inclusion criteria:

1. the presence of a severely resorbed mandible (class V–VI, Cawood & Howell 1988) with reduced stability and insufficient retention of the mandibular denture;
2. an edentulous period of at least 2 years;
3. no history of radiotherapy in the head and neck region;
4. no history of preprosthetic surgery or previously inserted oral implants.

The patients were informed about the two different treatment options and written informed consent was obtained from all participants. They were randomly assigned to a group receiving ITI implants (one-stage 4.1 mm solid screw ITI dental implants with a TPS coating, Straumann AG, Waldenburg, Switzerland), or to a group receiving IMZ implants (two-stage 4 mm IMZ cylinder implants with a TPS coating, Friedrichsfeld AG, Mannheim, Germany). Twenty patients were included in each group.

Treatment procedures

All patients received two implants in the canine region of the mandible. The implants were inserted under local anaesthesia, each about 1 cm from the midline. Implants were inserted by an experienced maxillofacial surgeon, according to a strict surgical protocol. The surgical procedure used for the ITI-implants has been de-

scribed previously (Sutter et al. 1988). The IMZ-implants were inserted as described by Kirsch (1983) but with the modification for a single-stage implantation procedure using a labial mucosa flap and connecting healing abutments as described previously (Heydenrijk et al. 2000). In none of the patients were palatal mucosa grafts placed. Post-operatively, analgesics and chlorhexidine 0.2% mouthrinse were prescribed for 14 days. Systemic or local antibiotics were not prescribed. Patients were not allowed to wear the mandibular denture during the first two postoperative weeks.

After 2, 6 and 12 weeks following the surgical procedure, the patients were recalled. At the first recall visit, sutures were removed and the mandibular denture was adjusted by selective grinding at the implant location and relining with Coe-soft (Coe laboratories, Inc. Chicago, IL, USA). At all recall visits, patients received oral hygiene instructions.

Three months after implant insertion, the manufacturing of a new maxillary denture and a mandibular overdenture was initiated. A uniform prosthetic procedure (Batenburg et al. 1993) was performed for all patients by one experienced prosthodontist. In the IMZ group, the healing abutments were replaced by 5-mm-high titanium connectors. A Dolder bar with subsequent clip attachment supported the overdentures. A balanced occlusion and monoplane articulation concept with porcelain teeth was used.

Outcome measures

Data collection was performed three times during the first year (T0 = baseline assessment 4 weeks after insertion of the new prosthesis; T6 = 6 months after T0; T12 = 12 months after T0).

Clinical outcome measures

The Mombelli index (score 0–3) was used to quantify the amount of plaque retained at four aspects of the surface of the supramucosal part of the implant (Mombelli et al. 1987). The highest value per implant was used for data-analysis. The presence (score 1) or absence (score 0) of calculus per implant was also recorded.

The degree of peri-implant inflammation was quantified by the mucosa score, i.e. the modified Löe and Silness index (Löe & Silness 1963), yielding a 0–3 score at each of four aspects of the implants. The highest score obtained per implant was used for data-analysis. In addition, the bleeding index according to Mühlemann & Son (1971) modified by Mombelli et al. 1987) was scored per implant (score 0–3).

The depth of the peri-implant 'sulcus' was measured mesially and distally of each implant to the nearest millimetre using a periodontal probe (Merrit B, Hu Friedy, Chicago, IL, USA) after removal of the bar (Quirynen et al. 1991). The distance between the marginal border of the mucosa and the tip of the pocket probe was scored as the probing pocket depth. The deepest pocket per implant was used for data-analysis.

The Periotest® device (Siemens, Bensheim, Germany) was used to quantify implant mobility (Teerlinck et al. 1991). Mobile implants were regarded as being lost and were removed.

Measurements were made by the same observer throughout the evaluation period after calibration.

Radiographic outcome

Standardised intraoral radiographs were made using the long cone technique with an aiming device (Meijer et al. 1992). The distance from a fixed reference point of the implants to the first bone-to-implant contact was measured with a digital calliper (Digitcal SI, Tesa SA, Renens, Switzerland) (Meijer et al. 1993). The measurements were made at the two approximal implant sites. The site showing most bone loss was used for data analysis. In the ITI group the neck of the implant and in the IMZ group the implant/connector interface was used as the reference point. From a previous study, addressing intra- and interobserver agreement of measurement of the level of bone, it was concluded that the reproducibility is more consistent if one experienced observer performs the measurements twice rather than two observers performing the measurements once (Batenburg et al. 1998a). Therefore, the measurements were performed twice by the same observer with a 2-week interval and averaged.

Microbiological sampling

Microbiological samples were obtained 12 months after functional loading of the implant (T12). Patients who had taken antibiotics during the previous 3 months were recalled for sampling 3 months later. Prior to probing pocket depth measurements, supra-mucosal plaque and calculus were carefully removed with sterile Teflon curettes and cotton pellets, after which the sample site was isolated with cotton rolls and gently air-dried. Sterile paper points (Fine, UDM, West Palm Beach, FL, USA) were inserted in the peri-implant sulcus and left in place for 10 s. Per implant the approximal sites were sampled twice. Per patient the paper points were collected in four separate vials containing 1.8 ml reduced transport fluid (RTF, Syed & Loesche 1972). The presence and proportions of *A. actinomycetemcomitans*, *P. gingivalis*, *Prevotella. intermedia*, *Bacteroides forsythus*, *Peptostreptococcus micros*, *Fusobacterium nucleatum* and *Campylobacter rectus* were assessed. Samples were processed in the laboratory within 6 h. Ten-fold serial dilutions of all samples were prepared in RTF. Aliquots of 0.1 ml were inoculated on 5% horse blood agar plates (Oxoid no. 2, Basingstoke, UK) with haemin (5 mg/l) and menadione (1 mg/l) for isolation and growth of obligately anaerobic bacteria, and on TSBV plates for selective isolation and growth of *A. actinomycetemcomitans* (Slots 1982). Blood agar plates were incubated anaerobically in 80% N_2 10% H_2 and 10% CO_2 for up to 14 days. TSBV plates were incubated in air with 5% CO_2 for 5 days (van Steenbergen et al. 1986). Blood agar plates were used for determination of the total number of colony forming units, the presence of dark-pigmented colonies, *B. forsythus*, *F. nucleatum* and *P. micros*. Representative dark-pigmented colonies were purified and identified using standard techniques (van Winkelhoff et al. 1985), including Gram-stain, fermentation of glucose, production of indole from tryptophan and production of specific enzymes (van Winkelhoff et al. 1986). *B. forsythus* was identified on the basis of the typical colony morphology, Gram-staining and production of trypsin-like enzyme (Braham & Moncla 1992). *F. nucleatum* and *P. micros* were identified on the basis of colony morphology, Gram-stain and production of specific enzymes (API 32 A, Biomerieux, La Balme, Les Grottes, France).

Data analysis

Qualitative data and quantitative data were analysed after categorisation using chi-square tests to assess differences in distribution between the two groups regarding

clinical, radiographic and microbiological parameters. Differences between quantitative variables were tested with the (paired) *t*-test if the population was normally distributed and with Wilcoxon's ranked sign test (paired data) or Mann–Whitney's test (independent data) if the criteria for using parametric tests were not fulfilled. The course of clinical and radiographic parameters within the groups during the evaluation period was evaluated with Friedman's test for more than two related samples. For all univariate tests, a significance level of 0.05 was chosen.

The strength of possible associations between clinical and radiographic parameters on the one hand and the presence of target microorganisms on the other was assessed with Spearman's rank correlation coefficient. A multiple stepwise regression analyses was performed to assess the joint contribution of the peri-implant mucosal condition (mucosa score, plaque score, pocket probing depth, bleeding score) and microbiological findings to the bone loss between T0 and T12.

Results

Loss of implants

At T0, one IMZ implant showed probing pockets depths of 12 mm and there were signs of inflammation (mucosa score 2), although the Periotest value was −3 and the implant did not show signs of mobility. Radiographic examination revealed a mesial bone defect of 10 mm and a distal bone defect of 3 mm. The implant was left in place, but at T6 it had to be removed because of increased mobility. Three weeks after removal, two new implants, one mesial and one distal to the former implant location, were successfully inserted.

Peri-implant parameters

The plaque scores in the ITI group were significantly higher that those in the IMZ group at T6 and T12 (chi-square test, $P = 0.05$ and $P = 0.006$, respectively, Fig. 1). The bleeding score in the IMZ group was significantly higher than in the ITI group at T0 (chi-square test, $P = 0.05$, Fig. 4). With regard to mucosa scores and the presence of calculus, no differences in distribution between the two groups were found (chi-square tests, $P > 0.05$, Figs 2 and 3).

In the IMZ group there was a significant reduction in the plaque score in the course of the observation period (Friedman test, $P = 0.04$, Fig. 1). In the ITI group there was a significant increase in the bleeding score (Friedman test, $P = 0.05$, Fig. 4). With regard to mucosa and calculus scores, no significant changes were found in the two groups during the observation period (Friedman test, $P > 0.05$, Figs 2 and 3). The difference between the probing pocket depths in the IMZ group and in the ITI group was significant at T0 (IMZ: mean 3.6 mm, median 3.0 mm, range 2–12; ITI: mean 2.4 mm, median 2.0 mm, range 1–5; Mann–Whitney $U = 334$, $P < 0.05$) as well as at T12 (IMZ: mean 3.3 mm, median 3 mm, range 1–5;

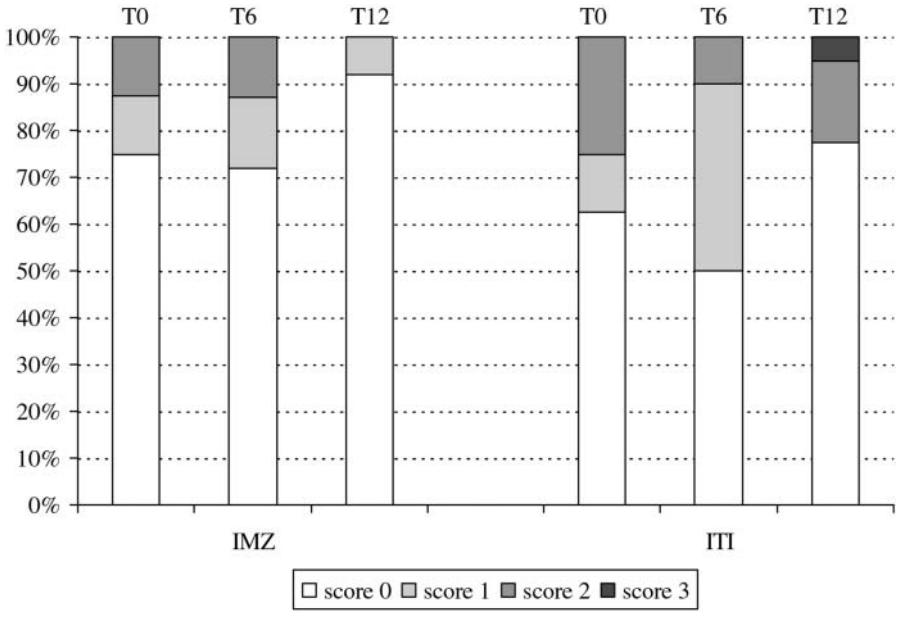

Fig. 1. Frequency distribution of the plaque scores at the baseline examination and 6 and 12 months after insertion of the overdenture. Score 0: no plaque, score 1: plaque detected by running a probe across the implant, score 2: plaque can be seen by the naked eye, score 3: abundance of plaque.

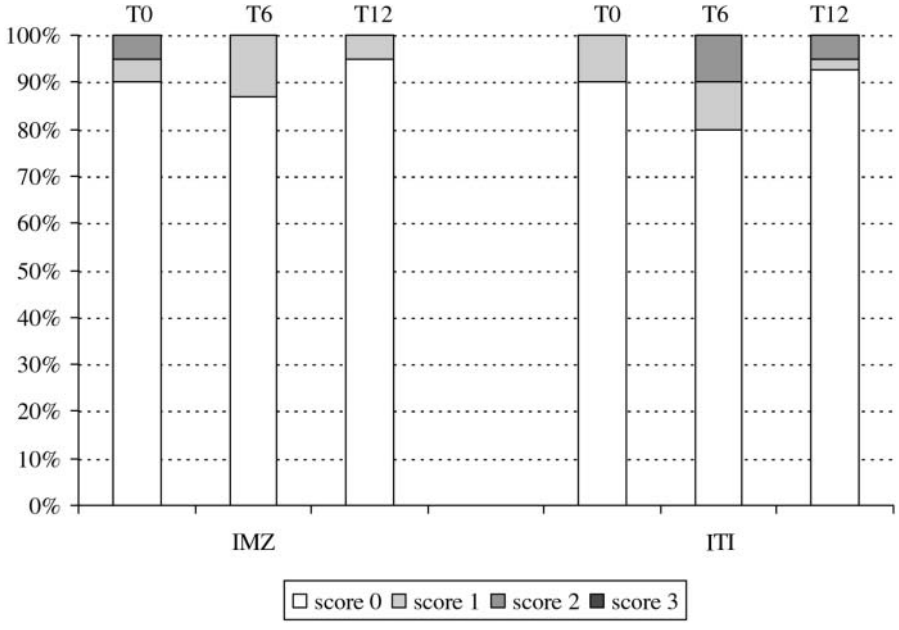

Fig. 2. Frequency distribution of the mucosa scores at the baseline examination and 6 and 12 months after insertion of the overdenture. Score 0: normal peri-implant mucosa, score 1: mild inflammation, score 2: moderate inflammation, score 3: severe inflammation.

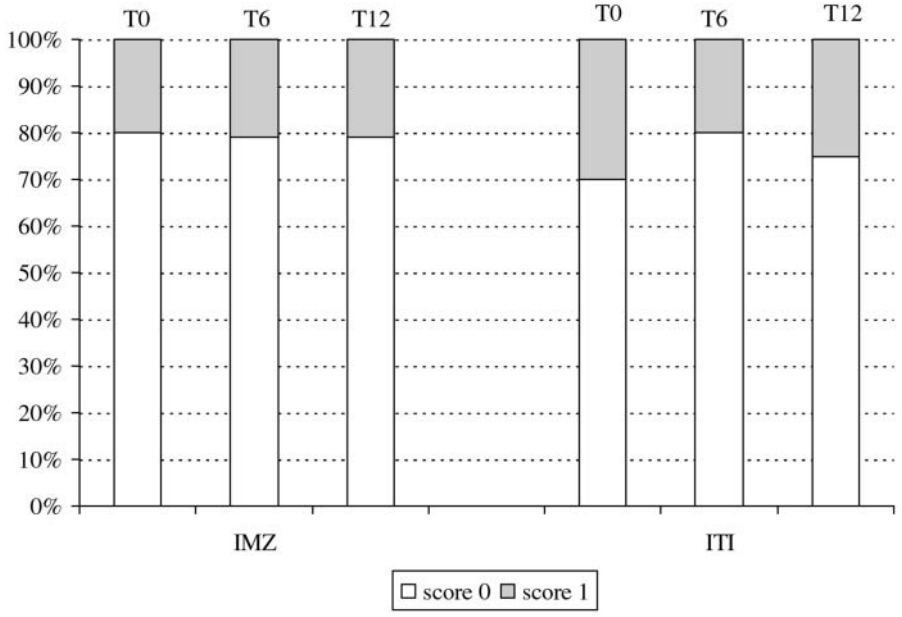

Fig. 3. Frequency distribution of the calculus scores at the baseline examination and 6 and 12 months after insertion of the overdenture. Score 0: no calculus, score 1: presence of calculus.

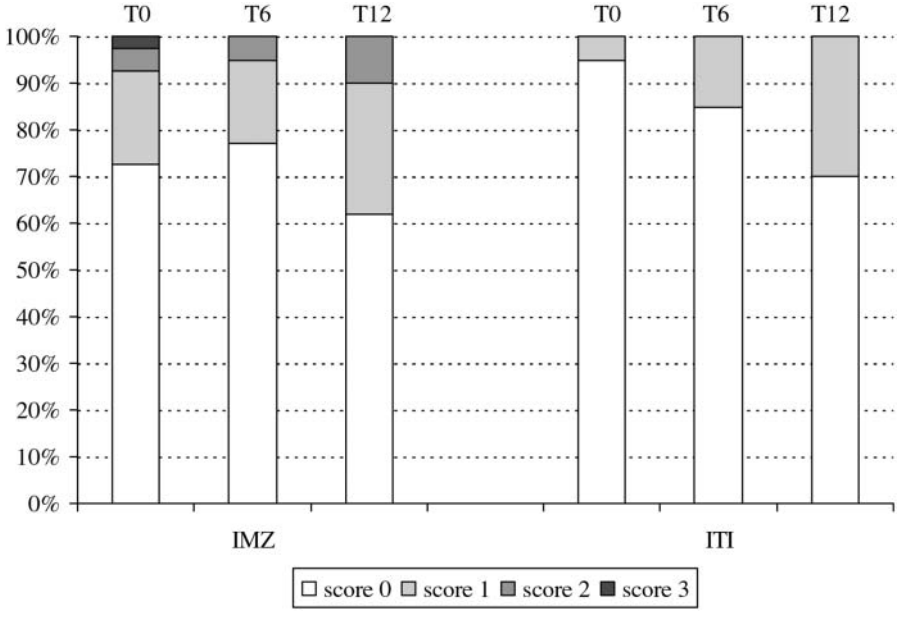

Fig. 4. Frequency distribution of the bleeding scores at the baseline examination and 6 and 12 months after insertion of the overdenture. Score 0: no bleeding after probing, score 1: isolated bleeding spots, score 2: confluent line of blood, score 3: heavy or profuse bleeding.

ITI: mean 2.9 mm, median 3 mm, range 1–5; Mann–Whitney U = 582, $P = 0.02$). At T12, the IMZ group showed significantly more implant sites with pockets ≥ 4 mm compared to the ITI group (chi-square test, $P = 0.04$, Table 1). In the ITI group, there was a significant increase in probing pocket depth during the observation period (Friedman test, $P = 0.007$). The periotest values were identical for both groups and ranged from −4.8 at T0 to −5.1 at T12.

Radiographic parameters

In two patients (one in the IMZ group and one in the ITI group) no standardised radiographs could be made of both implants, because the Dolderbar was placed labial to the implants to prevent interference with the floor of the mouth. Therefore, the radiographic observations of 38 IMZ and 38 ITI implants could be analysed. The mean amount of bone loss between T0 and T12 was 0.6 mm in both groups (ITI: SD = 0.8; IMZ: SD = 0.9). A multiple regression analysis did not yield a model relating clinical parameters and target microorganisms with the amount of bone loss between T0 and T12.

Microbiological parameters

Three patients had taken antibiotics during the previous 3 months for different medical purposes. They were recalled for sampling 3 months later. The mean number of colony forming units was $3.6 \cdot 10^5$ (SD = $6.9 \cdot 10^5$) in the IMZ group and $16 \cdot 10^5$ (SD = $47 \cdot 10^5$) in the ITI group, which was not significant different. *P. intermedia* was found significantly more often around ITI implants than around IMZ implants ($\chi^2 = 6.4$, $P = 0.01$, Table 1). *B. forsythus* was found at ITI sites only. *A. actinomycetemcomitans* was not found at any of the implant sites.

In the ITI group, several associations (Spearman's rho < 0.6 in all cases) between the clinical parameters and the presence of target microorganisms could be established (Table 1). These associations were not found in the IMZ group.

No bone loss between T0 and T12 was seen in 11 IMZ implants and four ITI implants. Bone loss was observed in 26 IMZ implants and in 34 ITI implants (Figs 5 and 6). These implants were divided into two subgroups, i.e. those with sites showing ≤ 1 mm bone loss and with sites with > 1 mm bone loss. No association could be demonstrated between the amount of bone loss and the presence of any of the target microorganisms (Table 1).

One IMZ implant site harboured *P. gingivalis* and showed bone loss of 1.6 mm between T0 and T12. Both ITI implants in one patient harboured *P. gingivalis* and these sites showed bone loss between T0 and T12 of 0.2 and 0.5 mm, respectively. Another ITI implant site harbouring *P. gingivalis* showed bone loss of 0.4 mm.

Discussion

This prospective randomised study is the first in which clinical, radiographic and microbiological results of two-stage non-submerged implants and one-stage im-

Table 1. **Results at T12. Number of implants with a mucosa score, plaque score, bleeding score ≥1 or a probing pocket depth ≥4 mm or with different amounts of bone loss between T0 and T12, colonised with the target organisms. Aa: A. actinomycetemcomitans, Pg: P. gingivalis, Pi: P. intermedia, Pm: P. micros, Bf: B. forsythus, Fn: F. nucleatum, Cr: C. rectus**

			Aa		Pg		Pi		Pm		Bf		Fn		Cr	
	IMZ	ITI	IMZ	ITI	IMZ	ITI	IMZ	ITI	IMZ	ITI	IMZ	ITI	IMZ	ITI	IMZ	ITI
All implants	39	40	0	0	1	3	3	12	8	8	0	5	30	32	3	2
Mucosa score ≥ 1	2	3	0	0	0	0	0	2	1	3*	0	1	2	3	0	0
Plaque score ≥ 1	3	9	0	0	0	3*	1	5	0	5*	0	3	3	9	0	1
Bleeding score ≥ 1	15	12	0	0	0	1	2	6	3	5*	0	4*	11	12*	0	2*
Pockets ≥ 4 mm	11	4	0	0	0	1	1	1	1	3*	0	1	8	4	0	0
No bone loss	11**	4**	0	0	0	0	1	2	3	1	0	1	10	6	0	1
Bone loss ≤ 1 mm	14	25	0	0	0	3	2	8	4	4	0	4	13	1	1	1
Bone loss > 1 mm	12	9	0	0	1	0	0	2	1	3	0	0	7	8	2	0

*Associations between clinical parameters and the target organisms are marked with an asterisk.

**In two patients no standardised radiographs could be made of both implants and one implant was lost. Therefore, the radiographic results were described of 37 IMZ and 38 ITI implants.

plants have been compared. Between-group differences primarily relate to microbiological issues. Only minor clinical differences and no important radiographic differences between the two groups were found in this study, suggesting that a two-stage implant system can be safely used for implant insertion in a nonsubmerged procedure.

At the 1-year evaluation (T12), 79 implants were successfully functioning. One IMZ implant had to be removed after 6 months of functioning. Because this implant already showed a severe peri-implant destruction at the beginning of the study without being mobile, it is likely that only partial osseointegration had occurred, which was insufficient to withstand the forces of the overdenture in function. Two new implants at a mesial and distal location of the old implant bed resulted in successful re-implants.

The clinical results are more or less comparable with the results in studies evaluating one-stage or two-stage implant systems (Cox & Zarb 1987; Mericske-Stern et al. 1994; Batenburg et al. 1998b; Heydenrijk et al. 1998). In the IMZ group, significantly more implants showed pockets ≥4 mm than in the ITI group. This difference might be attributed to the shape of the ITI implants, which can hamper easy insertion of the pocket probe (Spiekermann et al. 1995). The slight increase in average probing pocket depth in the ITI group is in agreement with the observations of Wismeijer et al. (1999).

Reproducible radiographs of sufficient quality are necessary in a longitudinal trial to detect the first bone to implant contact accurately. The intraoral radiographs used in the present study have been shown to satisfy this criterion (Batenburg et al. 1998a). The landmarks necessary for the evaluation were easy to identify. A major drawback of this technique is that the first radiograph can be obtained no sooner than after placement of the bar, which was at least 5 months after implant insertion. However, crestal bone loss around nonsubmerged implants has been shown to occur mainly within the first months after implant insertion (Hermann et al. 1997; Pham et al. 1994). Because no standardised intraoral radiographs could be made immediately after implant insertion, no information was available considering the initial bone level. The mean bone loss of 0.6 mm between T0 and T12 found in the ITI group of the present study was comparable to the results of other studies (Weber et al. 1992; Åstrand et al. 1996; Brägger et al. 1998; Batenburg et al. 1998b; Wismeijer et al. 1999). Two-stage implant systems show an average peri-implant bone loss in the first year ranging from 0.9 to 1.6 mm (Brägger et al. 1998). In the present study, a mean peri-implant bone loss of 0.6 mm was noticed in the IMZ group, suggesting that these implants are doing extremely well. However, implant sites with bone loss exceeding 1.0 mm between T0 and T12 were observed in both groups. Because this is substantially more than the average in our study, these implants are possibly at risk of failure and are therefore of special interest for long-term evaluation. These long-term evaluations will have to determine whether the bone loss is physiologic or pathologic and what factors are involved.

No correlation between the peri-implant mucosal aspects and bone loss between T0 and T12 was found, which has been reported earlier (Mericske-Stern et al. 1994; Batenburg et al. 1998b).

In our study we included edentulous patients because they provide a unique opportunity to study the colonisation of dental implants. Before implantation, these pa-

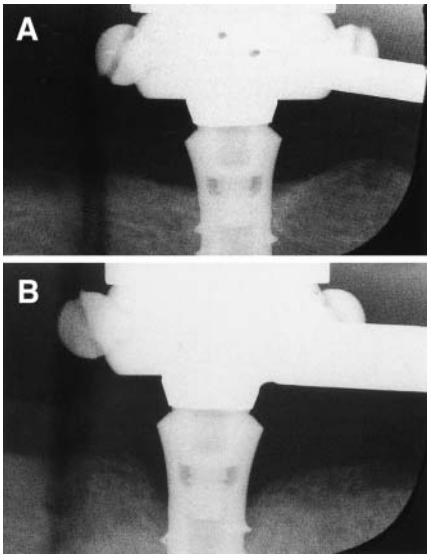

Fig. 5. (a) Radiographic view of an ITI implant without bone loss after 1 year. (b) Radiographic view of an ITI implant with bone loss after 1 year.

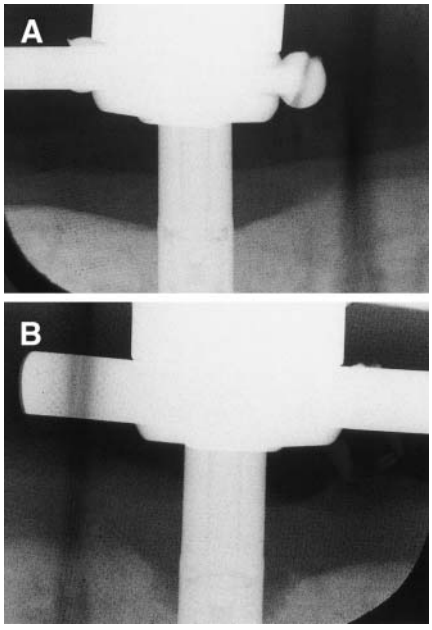

Fig. 6. (a) Radiographic view of an IMZ implant without bone loss after 1 year. (b) Radiographic view of an IMZ implant with bone loss after 1 year.

tients are devoid of tooth surfaces serving as sources for *A. actinomycetemcomitans* and *P. gingivalis* to colonise (Apse et al. 1989, Koka et al. 1993; Mombelli et al. 1995; Quirynen & Listgarten 1990, 1996; Lee et al. 1999; Van Winkelhoff et al. 2000). Therefore, edentulous patients are only rarely colonised by *A. actinomycetemcomitans* and *P. gingivalis* (Danser et al. 1997), although in three patients of the present study *P. gingivalis* was cultured which is probably due to transmission from another subject (Danser et al. 1998).

Mombelli et al. (1988) concluded that one-stage implants in edentulous patients were colonised by a microflora similar to the microflora of the oral mucosal surfaces before implantation. Therefore, the implants were colonised by predominantly facultative cocci associated with periodontal health. Moreover, these authors concluded that the colonisation was established quite soon after implantation and that no important shifts in the composition could be demonstrated over time.

The mean number of colony forming units found around the ITI implants of the present study are comparable with other studies evaluating stable ITI dental implants in edentulous patients (Mombelli et al. 1987, 1988). It is likely that marginal bone resorption around an ITI implant is related to exposure of a rough surface. The rough/smooth interface of the ITI implants is located at crestal level, while in the IMZ implants this interface is located approximately 1 mm deeper. It seems likely that this rough surface exposure favours microbial colonisation. However, despite the difference in plaque score, no significant difference was found between the amounts of colony forming units of the two implant types.

In three recent studies, the submucosal microflora around IMZ implants were evaluated (Danser et al. 1997; Pontoriero et al. 1994; Augthun & Conrads 1997). Because of the differences in study design, the results of the two latter studies were difficult to compare with the present study. In the study of Pontoriero et al. (1994), implants were inserted in partially edentulous patients with a history of moderate advanced periodontitis and only bacterial morphotypes were enumerated instead of bacterial determination, as used in the present study. In the study of Augthun et al. (1997) edentulous patients with IMZ implants showing bone loss exceeding 5 mm were included. A high incidence of *A. actinomycetemcomitans* and *P. intermedia* and a low incidence of *F. nucleatum* were observed. The high incidence of *A. actinomycetemcomitans* observed in edentulous patients in this study was particularly striking, although *A. actinomycetemcomitans* has recently been found in an edentulous patient (Van Winkelhoff & Wolf 2000). In the present study, *A. actinomycetemcomitans* was not detected and a low incidence of *P. intermedia* and a high incidence of *F. nucleatum* were observed around the IMZ implants. The major reason for the differences in results probably relates to the inclusion of only failing implants in the study of Augthun et al. (1997). In the study of Danser et al. (1997), in which 20 edentulous patients were treated with either IMZ or Brånemark implants, a microbiota associated with periodontal health was found. *A. actinomycetemcomitans* and *P. gingivalis* were not detected. These authors reported a peri-implant microflora comparable with that around the IMZ implants of our study.

Three studies report the colonisation of stable ITI implants in edentulous patients (Mombelli et al. 1987, 1988; Mombelli & Mericske-Stern 1990). *P. gingivalis* was not isolated and *P. intermedia* and *Fusobacterium* species were found only occasionally. These results differ from those found in our study, which cannot be explained by differences in study design. The most plausible explanation for the higher incidence of *P. intermedia* and *B. forsythus* in the ITI group of our study was the higher plaque scores in this group, although no significant association between these parameters was found.

Several studies showed associations between clinical parameters and the peri-implant microflora. A trend was found between the bleeding index and the proportion of motile organisms in edentulous patients (Papaioannou et al. 1995). For increasing pocket depths, a significant decline in cocci and a significant increase for other morphotypes (motiles and Spirochetes) as well as the total number of organisms was observed (Sanz et al. 1990; Rams et al. 1991). In the study of Mombelli & Mericske-Stern (1990) the relative proportion of *Capnocytophaga* was significantly related to probing pocket depth, and in the study of Danser et al. (1997) all subjects harbouring *P. intermedia* showed pockets >4 mm. In the study of Keller et al. (1998), *Fusobacterium* species and *P. intermedia* were found in significantly higher numbers in the deeper periodontal pockets. However, in several other studies no correlation was established between the frequency of any group of microorganism and the clinical parameters (Lekholm et al. 1986b; Adell et al. 1986; Apse et al. 1989, Mombelli et al. 1995; Sbordone et al. 1999). In the ITI group, we found several weak associations between clinical parameters and the presence of the target microorganisms, to which no clinical significance can be attributed. No association was found between the presence of any of the target microorganisms and the amount of bone loss. In three patients of the present study, *P. gingivalis*, which is considered to be the most periodontopathic species in adults, was cultured. Although the amount of bone loss during the first year of loading (between 0.2 and 0.5 mm) could be considered normal in two patients, the bone loss of 1.6 mm between T0 and T12 observed in the third patient might suggest a possible association with the presence of *P. gingivalis*.

Although suspected periodontal pathogens were identified at implant sites in the present study, the clinical and radiological parameters were not indicative of deterioration, suggesting that the presence of potential periodontal pathogens around implants is not necessarily associated with future attachment loss or implant failure. However, it is possible that, as in the dentate situation, elevated numbers of these bacteria need to be present for extended periods of time to have an adverse impact on the tissues (Mombelli et al. 1995). From the periodontal literature it has become evident that periodontal pathogens are essential for the onset and progression of destructive periodontal disease, but interpatient variability in the host response is a major determinant of the expression of periodontal disease. In the implant literature there are indications that implant failure is primarily at a patient level and secondarily at implant level from a clinical or microbial perspective (Salcetti et al. 1997; Kronström et al. 2000). The question of susceptibility to infection of peri-implant tissue in the presence of these organisms might be answered in the long-term evaluation of our patients.

Conclusions

The results of this study indicate that dental implants designed for a submerged implantation procedure can also be used in a single-stage procedure and may be as predictable as one-stage implants. The microgap at crestal level in nonsubmerged implants appears to be of no importance in the establishment of the submucosal microbial flora and crestal bone loss during the first year of functioning.

Résumé

Le but de cette étude a été d'évaluer la possibilité d'utiliser le système implantaire en deux étapes lors d'un processus en une étape, d'étudier l'impact du mini-sillon au niveau crestal et d'évaluer la microflore paroïmplantaire. Quarante patients édentés (classe V et VI de Cawoode et Howell) ont participé à cette étude. Après randomisation, vingt patients ont reçu deux implants IMZ insérés en une étape et vingt autres ont reçu deux implants ITI. Après trois mois, des prothèses amovibles s'insérant par une barre ou une attache ont été fabriquées . Une évaluation standard clinique et radiographique a été effectuée juste après l'insertion de la prothèse, et six et douze mois plus tard. Douze mois après la mise en charge, des échantillons paroïmplantaires ont été prélevés à l'aide de pointes en papier stériles et analysés pour détecter la présence de pathogènes parodontaux putatifs en utilisant des techniques de cultures. Un implant IMZ a été perdu à la suite d'une ostéoïntégration insuffisante. En ce qui concerne les paramètres cliniques à douze mois, des différences significatives pour les scores de plaque dentaire et de profondeur au sondage ont été trouvées entre les deux groupes (IMZ : moyenne 3,3 mm, ITI : moyenne 2,9 mm). La perte osseuse moyenne durant la première année de mise en fonction était de 0,6 mm pour les deux groupes. Le *Prevotella intermedia* a été détecté plus souvent dans le groupe ITI (douze implants) que dans le groupe IMZ (trois implants). Le *Porphyromonas gingivalis* a été trouvé chez trois patients. Chez un de ces individus, un implant a subi une perte osseuse de 1,6 mm entre T0 et T12. Quelques associations ont été trouvées entre les paramètres cliniques et les micro-organismes recherchés dans le groupe ITI. Ces associations n'étaient pas présentes dans le groupe IMZ. Ces résultats à court terme indiquent que les implants en deux étapes insérés en une étape peuvent être aussi sûrs que les implants placés en une étape. Les mini-sillons au niveau crestal autour des implants IMZ non-enfouis ne semblent pas avoir d'influence néfaste sur la colonisation microbienne paroïmplantaire ni sur la perte osseuse crestale durant la première année de mise en fonction. Le sillon paroïmplantaire contient et peut contenir des pathogènes parodontaux potentiels sans signe de paroïmplantite durant une année.

Zusammenfassung

Das Ziel dieser Studie war es, die Verwendbarkeit eines zweiphasigen Implantatsystems zur transmukosalen Plazierung zu untersuchen. Der Einfluss der Mikrospalte auf Höhe des Knochenkamms sollte ergründet werden und die Mikroflora in der peri-implantären Region wurde untersucht.

An der Studie nahmen 40 zahniose Patienten (Cawood & Howell Klasse V-VI) teil. Nach zufälliger Aufteilung erhielten 20 Patienten 2 IMZ Implantate, welche transmukosal eingesetz wurden, und 20 Patienten wurden mit 2 ITI Implantaten versorgt. Nach drei Monaten wurden Hybridprothesen angefertigt, welche mit einer Steg/Reiter-Verankerung befestigt wurden. Eine standardisierte klinische und radiologische Untersuchung wurde unmittelbar nach Eingliederung der Prohtesen und in der Folge nach 6 und 12 Monaten durchgeführt. Zwölf Monate nach der initialen Belastung wurden mit sterilen Papierspitzen peri-implantäre Proben entnommen und mittels Kulturtechniken auf das Vorhandensein von potentiell parodontalpathogenen Keimen untersucht. Ein IMZ Implantat ging wegen ungenügender Osseointegration verloren. In Bezug auf die klinischen Parameter zum Zeitpunkt der Untersuchung nach 12 Monaten konnten für die Plaquewerte und die Sondiertiefen (IMZ: Mittelwert 3.3mm; ITI: Mittelwert 2.9mm) signifikante Unterschieden zwischen den beiden Gruppen gefunden werden. Der mittiere Knochenverlust im ersten Jahr in Funktion betrug für beide Gruppen 0.6mm. *Prevotella intermedia* wurde mehr in der ITI Gruppe (12 Implantate) als in der IMZ Gruppe (3 Implantate) gefunden. *Porphyromonas gingivalis* wurde bei 3 Patienten entdeckt. Bei einem dieser drei Patienten zeigte ein Implantat einen Knochenverlust von 1.6mm zwischen T0 und T12. Bei der ITI Gruppe konnten zwischen den klinischen Parametern und den Zielorganismen gewisse Zusammenhänge gefunden werden. Diese Zusammenhänge waren in der IMZ Gruppe nicht vorhanden.

Die Kurzzeitresultate zeigen, dass zweiphasige Implantate, welche transmukosal eingesetzt werden, genau so zuverlässig wie einphasige Implantate sein können. Die Mikrospalte auf Höhe des Knochenkammes bei transmukosal eingesetzten IMZ Implantaten scheint keinen nachteiligen Einfluss auf die peri-implantäre mikrobielle Besiedelung und auf den Knochenverlust im ersten Jahr der Belastung zu haben. Der peri-implantäre Sulcus kann potentielle Parodontalpathogene enthalten ohne dass während der Beobachtungszeit von einem Jahr Zeichen einer Peri-Implantitis auftreten.

Resumen

La intención de este estudio fue evaluar si era factible usar un sistema de implantes de dos fases un procedimiento de una sola fase y estudiar el impacto del microhueco en el nivel crestal monitorizar la microflora en el área periimplantaria.

En este estudio participaron cuarenta pacientes edéntulos (Cawood & Howell clase V–VI). Tras distribuirlos aleatoriamente, 20 pacientes recibieron 2 implantes IMZ insertados mediante un procedimiento de una sola fase y 20 pacientes recibieron 2 implantes ITI. Tras 3 meses, se fabricaron sobredentaduras soportadas por barras y ataches de clip.

Se realizó una evaluación clinica y radiográfica estandarizada inmediatamente tras la inserción de la dentadura y a los 6 y 12 meses posteriores.Tras 12 meses de carga, se tomaron muesiras periimplantarias con puntas de papel estériles y se analizó la presencia de patogenos periodontales putativos usando técnicas de cultivo. Se perdió un implante IMZ debido a insuficiente osteointegración. Respecto a los parámetros clinicos en la evaluación de los 12 meses, se encontraron diferencias significativas entre los dos grupos en los índices de placa y la profundidad de sondaje (IMZ: media 3.3 mm; ITI: media 2.9mm). La perdida de hueso media en el primer año de función fue de 0.6 mm para ambos grupos. Se detectó *Prevotella intermedia* mas frecuentemente en el grupo ITI (12 implantes) que en el grupo IMZ (3 implantes). Se encontró *Porphyromonas gingivalis* en 3 pacientes. En una de estos pacientes un implante mostró una perdida de soporte de 1.6 mm entre T0 y T12.Se encontraron algunas relaciones entre los parámetros clinicos y los microorganismos diana en el grupo ITI. Estas relaciones no se encontraron en el grupo IMZ.

Los resultados a corto plazo indican que los irnplantes de dos fases insertados con un procedimiento de una sola fase puede ser tan predecible como los implantes de una sola fase. El microhueco en el nivel crestal en los implantes IMZ no sumergidos parece no tener una influencia adversa en la colonización microbiológica periimplantaria y en la perdida de hueso crestal en el primer año de función. El surco periimplantario puede recibir y recibe potenciales patógenos periodontales sin signos de periimplantitis durante el periodo de evaluación de un año.

要旨

本研究では２回法のインプラントを１回法で植立する術式の有効性を評価し、骨頂レベルの微小空隙が及ぼす影響を調べ、インプラント周囲の細菌叢を追跡調査した。

本研究には４０名の無歯顎患者（Cawood & Howell クラス V-VI）が参画した。無作為化のあと、患者２０名は２本の IMZ インプラントを１回法で植立し、残り２０名の患者は２本の ITI インプラントを植立した。３ヵ月後にバーまたはクリップ・アタッチメントを備えたオーバーデンチャーを製作した。標準化した臨床的診査とレントゲン評価を義歯装着直後、６ヵ月後及び１２ヶ月後に行った。荷重１２ヶ月後にインプラント周囲の細菌標本を滅菌ペーパーポイントで採取し、培養法で想定歯周病原菌の存在を調べた。IMZ インプラント１本は骨性統合が不十分なために失われた１２ヶ月後に評価した臨床的パラメータに関しては、プラーク・スコアとプロービング・ポケットの深さに２群間で有意な差が認められた（IMZ: 平均＝３．３ｍｍ、ITI：平均＝２．９ｍｍ）。機能初年度の平均骨喪失量は両群とも０．６ｍｍであった。Prevotella intermedia は IMZ 群（３本）より ITI 群（１２本）の方に多く検出された。Porphyromonas gingivalis が３人の患者から検出された。これら３人のうち１人では、インプラント周囲の骨が T0 と T12 の間で１．６ｍｍ失われた。ITI 群では臨床的パラメータと目標細菌の間に何らかの関連性が認められたが、IMZ 群では関連性は認められなかった。

短期調査の結果は、２回法のインプラントを１回法で植立する術式は、１回法のインプラントと同様に予知性が高いことを示している。骨内に埋め込まない場合に生じる IMZ インプラントの骨頂レベルの微小空隙は、インプラント周囲の細菌のコロニー化及び機能初年度の骨喪失に対して悪影響を及ぼさないと思われる。１年の評価期間中にインプラント周囲炎の徴候がない場合でも、インプラント周囲歯肉溝には想定歯周病原菌が存在する可能性がある。

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