

A Follow-up Study of Maxillary Implants Supporting an Overdenture: Clinical and Radiographic Results

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Purpose: Studies of maxillary overdentures supported by endosseous implants often show a high implant failure rate. The aim of the present investigation was to evaluate clinically and radiographically non-submerged implants supporting an overdenture in the maxilla. **Materials and Methods:** Forty-one patients were consecutively admitted for treatment. The standard procedure was to place 4 implants and to mount a U-shaped bar for overdenture connection. When the overdenture was delivered to the patients, peri-implant parameters were recorded and radiographs were taken. All patients were required to follow a maintenance care program. In the context of this study, all patients were clinically examined and the peri-implant parameters were compared. Crestal bone loss was analyzed using linear radiographic measurements. A life table analysis was applied to calculate the cumulative survival rate (CSR). **Results:** Three implants failed in the early healing phase, and 3 patients lost 6 implants during the loading period. The 5-year CSR of all implants was 94.2%. The peri-implant parameters gave evidence of healthy soft tissues and good oral hygiene. The increases in probing depths and attachment loss were significant ($P < .05$). The mean marginal crestal bone loss was about 0.7 mm and was statistically significant at mesial and distal sites ($P < .001$). **Discussion:** The correlation between clinical attachment loss and crestal bone loss was not significant. Pronounced marginal bone loss was found around some implants. **Conclusion:** In planned maxillary overdenture treatment, it is possible to achieve a satisfactory survival rate of the implants. (INT J ORAL MAXILLOFAC IMPLANTS 2002;17:678-686)

Key words: dental implants, edentulous maxilla, overdentures, peri-implant parameters, radiographic measurements

Overdentures supported by a few implants¹⁻³ appear to be highly successful in the edentulous mandible.⁴ In contrast, treatment outcome with maxillary overdentures seems to be less predictable in comparison to other prosthetic implant indications. While long-term studies are available with reliable results on fixed prostheses supported by implants in the edentulous jaw,^{1-3,5-7} an overview of maxillary overdenture studies⁸ reveals a rather

low implant survival rate. Early failure rates of 2% to 5% or more have frequently been observed in the maxilla,⁹⁻¹² and up to 30% of the loaded implants may be lost even after a short observation period. It has also been reported that a few patients lost a majority or all of their implants.¹¹⁻¹⁶ In general, maxillary implants appear to cause more problems than mandibular implants supporting overdentures.^{9,12,17-19}

Some of these reports made a distinction between the degree of atrophy in the maxilla and also gave results for subgroups related to good or poor bone quality. Generally, problems were frequent in patients with poor bone quality, short implants, and severely resorbed maxillae, and these criteria were generally indications for overdenture placement. In fact, indications for overdentures in the maxilla have mostly been made on the basis of the limited number of implants that could be placed or that were stable at stage 2 surgery.^{6,7,9,12,17}

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Table 1 Dimensions of 173 Placed Implants

Implant length	Implant diameter (mm)			Totals
	4.1	3.3	4.8	
6 mm	2	—	2	4
8 mm	23	20	4	47
10 mm	37	32	—	69
12 mm	32	21	—	53
Total*	94	73	6	173*

*Includes early implant failures.

Palmqvist and coworkers²⁰ recognized this problem and made a distinction between planned overdenture treatment and emergency situations. They found a much better survival rate (over 90%) for planned cases. Implant survival in connection with maxillary overdentures was clearly increased where good bone quality was present.²¹ Healthy marginal soft tissues and rather stable marginal bone were found around implants with normal bone conditions.^{13,21} In a multicenter study with ITI implants,²² good results were reported for a few maxillary overdentures; however, the small number of implants and the short observation period did not permit conclusions to be drawn.

The aim of the present follow-up study was to evaluate the survival rate and to assess peri-implant and radiographic parameters of non-submerged implants in planned maxillary overdenture cases.

MATERIALS AND METHODS

Patients

From 1991 through 1998, 41 patients (17 men and 24 women), each with an edentulous maxilla, were admitted consecutively for treatment with implant-supported overdentures. The average age at the time of overdenture connection was 61.2 years (range, 40 to 89 years). At the time of data collection for the present study, the overdentures had been in situ for at least 1 and up to 9 years, with an average of 4.1 years.

Inclusion criteria were:

- Adequate width and height of maxillary ridge bone for the placement of 4 implants
- No severe systemic problems; patient able to undergo surgery
- No heavy smoking (less than 15 cigarettes per day) and no abuse of drugs
- Good oral hygiene and periodontal health of remaining teeth in the mandible

- Periodontal treatment of the mandibular teeth (if needed) preceding implant surgery

Graft procedures for vertical bone augmentation or sinus floor elevation had not been performed in these patients. However, simultaneous lateral bone augmentation using non-resorbable membranes became necessary for several implants during the surgical placement.

In the opposing mandible, 16 patients had natural teeth, and 4 patients had a combination of natural teeth with fixed prostheses supported by implants. One patient had a fixed prosthesis supported by implants only, 9 patients had a removable partial denture, and 11 patients had received an implant-supported overdenture in the edentulous mandible also.

In the context of this study, the patients were classified into 3 time groups according to the observation period:

- Group 1: ≤ 2 years of observation; 9 patients (initial observation phase)
- Group 2: $> 2 \leq 5$ years of observation; 21 patients (short-term observation phase)
- Group 3: > 5 years of observation; 11 patients (medium-term observation phase)

Treatment Protocol

Treatment was designed to follow a standard protocol.^{23,24} The standard procedure was to place 4 to 6 screw-type ITI implants (Straumann, Waldenburg, Switzerland), well spaced, in the anterior part of the maxilla. The number was dependent on the size and curvature of the maxilla. For specific anatomic reasons (cleft palate situation, defect related to trauma) 1 patient received 8 implants, and 3 patients received 3 implants each. Because of the extension of the sinus, implants were often located in the zone between the left and right first premolars. However, some patients also had implants placed in a posterior



Figs 1a and 1b Clinical situation showing (left) 4 maxillary implants with a connecting bar and (right) the inner surface of the overdenture with retainers.

zone (second premolar or first molar) depending on their individual anatomy. The number of implants per overdenture was 4 in 70% of the patients. The intraosseous implant length varied from 6 to 12 mm, and the diameter was 4.1 mm (standard diameter) or 3.3 mm (reduced diameter). For 2 patients, 4.8-mm (wide-diameter) implants were used. Table 1 shows the distribution of implant lengths and diameters. With respect to the bone quality and quantity of the maxilla according to the definition by Lekholm and Zarb,²⁵ 63 implants (36.5%) were in Type 2 bone quality, 65 (37.5%) were placed in Type 3 bone, and 45 (26%) were in Type 4 bone. Sixty-nine implants (40%) were placed in Type B bone quantity, 54 (31%) were placed in Type C bone, and 50 (29%) were placed in Type D bone quantity.

Prior to surgery, optimal location of the implants was assessed using panoramic radiographs with metallic landmarks, and in a few cases computed tomographic scans were prescribed. Radiographs had been taken on an individual basis immediately after surgery and, in a few patients, during the healing phase. After implant surgery, a healing period of at least 4 to 6 months was observed before prosthetic treatment took place. During the healing phase, the patients were required to maintain good oral hygiene, especially since the implants were placed in a 1-stage, non-submerged procedure. The time lag between implant surgery and delivery of the new overdenture varied between 5.1 (minimum) and 7.8 (maximum) months. After completion of the prosthetic treatment, all patients were included in a strict maintenance care program, with regular monitoring at individual intervals of 4 to 6 months by the dental hygienist and, if necessary, by the dentist. These examinations included assessment of oral hygiene, bleeding on probing, and probing depth exceeding 4 mm. During the entire follow-up period reported in the present study, records were kept regularly.

Overdentures and Anchorage Devices

Thirty-three patients received an overdenture supported by implants and connected by a U-shaped Dolder bar (Cendres Métaux, Biel, Switzerland). When this type of bar was used, a rigid connection of the overdenture to the implants resulted. Eight overdentures were connected to single abutments; either ball anchors (19 implants) or telescopic copings (10 implants). All overdentures had a horseshoe design (Figs 1a and 1b) and were reinforced by a cast framework.²³

Data Collection

At the appointment when the prosthodontic treatment was completed and the overdenture delivered to the patient, a panoramic radiograph was taken. In addition, peri-implant parameters were recorded according to the proposed criteria by Mombelli and coworkers²⁶ at all 4 implant sites. This included Plaque Index (PLI), Bleeding Index (BI), probing depth (PD), and probing attachment level (PAL) related to the implant shoulder (Fig 2). Radiographs were not taken regularly (ie, annually) for all patients, since most patients did not provide consent. Thus, a standardized evaluation of the peri-implant bone level with calculations of mean annual bone loss was not possible.

In the context of the present study, all patients were recalled and clinically examined by 2 investigators. Peri-implant parameters were recorded again for all patients and radiographs were taken. Thus, the mean time difference between the first and last radiographs corresponded to the observation period of 4.1 years (1 to 9 years). The radiographic distance DIB (distance from implant shoulder to first bone contact) (Fig 2) was calculated at mesial and distal sites, according to the method of linear measurements.²⁷ The implant features, with design characteristics of known size, facilitated radiographic measurements of crestal bone

level at the approximal sites. Changes in the adjacent crestal bone level (DIB diff) were calculated by comparing the distance DIB on both radiographs (DIB diff = second reading minus first reading). The difference between the PAL (PAL diff) was also determined (PAL diff = second minus first record). In a pilot exercise, 3 examiners were trained, 2 to analyze the radiographs, 1 to record the peri-implant parameters. They had to perform all measurements in 5 patients under supervision of the study director. Then, 1 examiner assessed the peri-implant parameters, while another examiner scored all assessments of the peri-implant bone levels on the radiographs. These radiographic measurements were repeated by the third examiner, and differences in measurements were recalculated and adjusted. Prosthetic results have been published in a separate paper.²⁸

Statistical Analysis

Descriptive statistics were used for patients' demographics, implant distribution, and overdenture type. The cumulative implant survival rate was calculated using a life table analysis. In the context of this study, survival means that the loaded implant was stable in situ with healthy marginal soft tissues without discomfort or pain. Survival also included implants that required some treatment during the observation phase, eg, because of peri-implant lesions, but were successfully maintained after interceptive therapy. For comparisons of periodontal parameters, the Kruskal-Wallis test was used. The Wilcoxon matched pairs signed rank test was applied for comparisons of crestal bone level changes. The Pearson correlation between changes of probing attachment level (PAL diff) and radiographic bone measurements (DIB diff) was calculated.

RESULTS

Implant Survival

In the time period from 1991 to early 1998, a total of 173 implants were placed, and 3 implants were lost during the healing phase. Two of these implants had a length of 6 mm, and 1 was 8 mm long. At the time the overdentures were placed, 170 stable implants showed clinical signs of osseointegration. Thus, an implant survival rate of 99.3% was achieved after the healing phase. In spite of these 3 implant losses during the healing phase, all patients could be treated as planned with overdentures. No patient had dropped out definitively from the study during the entire period, but temporary dropouts for various reasons occurred with 3 patients, in the first, second, and third years of observation.

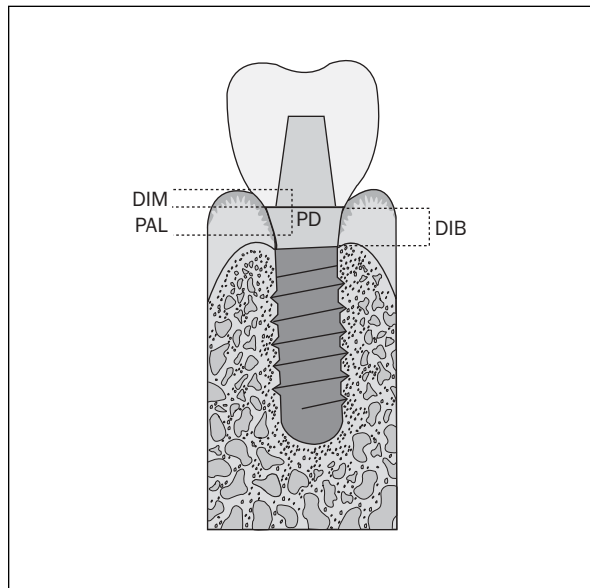


Fig 2 Schematic illustration of peri-implant measurements. DIM = distance from implant shoulder to gingival margin, which would show a positive value if the gingival margin was located above the implant shoulder and a negative value if it was located underneath; PD = penetration depth of the probe; DIB = distance from implant margin to first bone contact, as measured radiographically; PAL (probing attachment level) = PD - DIM.

During the loading period, 6 implants had to be removed, 2 with a length of 8 mm, 3 with a length of 10 mm, and 1 with a length of 12 mm. Four implants were lost in a patient who had already lost 2 implants during the healing phase. These implants exhibited slight mobility without signs of peri-implant marginal infection. This patient returned to using a complete maxillary denture. Two further implants in 2 patients were lost because of a marginal infection that could not be treated successfully with antimicrobial therapy. These 2 patients continued to wear the overdenture. No implant fractures were observed. Thus, at the time of the last clinical examination in the context of this study, 164 implants were still in situ in 40 patients. Table 2 shows the life table analysis for the implants with interval and cumulative survival rates. A 5-year cumulative survival rate of 94.2% was found.

Peri-implant Parameters

Table 3 shows mean values for the peri-implant parameters, ie, PD and PAL. Most patients exhibited good oral hygiene, and the implants were often free of any plaque and calculus deposits. The number of sites with a PLI and BI of 0, 1, 2, or 3 did not change significantly. However, PD and attachment loss increased at a significant level ($P < .05$).

Table 2 Life Table Analysis: Survival of 173 Placed Implants

Interval (y)	No. of implants at start of interval	Drop-out during interval		Implants under risk	Failures during interval*	Survival rate within interval (%)	Cumulative survival rate (%)
		No. of implants	No. of patients				
Placement to loading	173	0	0	173	3	98.3	98.3
Loading to 1 y	170	3	1	167	0	100	98.3
1 to 2 y	148	4	1	144	1	99.4	97.8
2 to 3 y	109	4	1	105	4	96.2	94.2
3 to 4y	78	0	0	78	0	100	94.2
4 to 5 y	50	0	0	50	0	100	94.2
> 5 y	36	0	0	36	1	97.3	91.6

*Thirty-eight of the 41 patients experienced no implant losses.

Table 3 Comparison of Peri-implant Parameters

Parameters	After Healing		After loading		P value*
	Mean	SD	Mean	SD	
PD	2.7	0.7	2.9	0.8	< .05
PAL	2.4	0.9	2.6	1.1	< .05

*Kruskal-Wallis test.

Table 4 Comparison of DIB According to Time Groups

Time group	Mesial sites (Mean ± SD)			Distal sites (Mean ± SD)		
	After healing	After loading	P value	After healing	After loading	P value
1	2.6 ± 0.8	3.0 ± 1.0	< .05	2.8 ± 1.0	3.2 ± 0.9	< .05
2	2.5 ± 0.9	3.3 ± 1.3	< .001	2.6 ± 0.9	3.5 ± 1.2	< .001
3	2.7 ± 0.9	3.4 ± 1.1	< .01	2.9 ± 0.9	3.6 ± 1.1	< .01
Overall total	2.6 ± 0.9	3.3 ± 1.2	< .001	2.8 ± 1.0	3.5 ± 1.1	< .001

Wilcoxon matched pairs signed rank.

Radiographic Results

Readable radiographs of 158 implants were available for comparative measurements. Table 4 shows the mean values of linear radiographic measurements (DIB) recorded at both clinical examinations. For all 3 groups, a significant difference was calculated between the readings. The mean bone loss at both sites was approximately 0.7 mm. Among the 3 groups the difference was not significant. Forty implants exhibited no negative changes in the crestal bone level and no measurable increase in the crestal bone level (up to 1 mm) at both implant sites. Forty-nine implants lost crestal bone at both implant sites, which means that a decrease of vertical bone height of ≥ 1 mm during the observation period was measured. On the radiographs of several implants, a visible increase in peri-implant bone density was detected (Fig 3). Around 5 implants,

probing depths of 7 or 8 mm were found, associated with radiographically visible decrease of the crestal bone (Fig 4). These implants appeared clinically stable at the last clinical examination and did not show signs of mobility, suppuration, or active peri-implant lesions. A tendency was observed that crestal bone loss, ie, an increase in DIB, corresponded to the loss of clinically measured attachment (PAL), but the Pearson correlation coefficient was not significant at mesial and distal sites (Figs 5a and 5b).

DISCUSSION

Poor bone quality and low quantity are a problem, particularly for the edentulous maxilla, which has shown a higher susceptibility to implant loss.²⁹ On a clinical basis the selection of short implants^{22,30}

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Fig 3 Radiograph showing increased bone density around implant body (arrow).

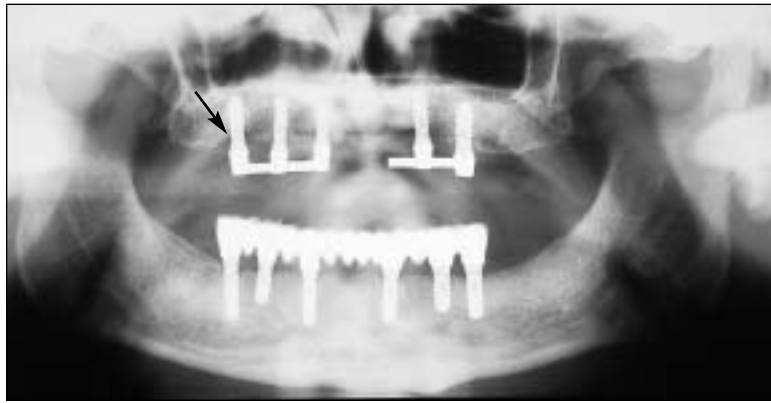


Fig 4 Radiograph showing advanced bone loss around implants after a short observation period (arrow).



Figs 5a and 5b Scatterplots showing the correlation between changes in probing attachment level (PAL diff) and radiographically measured crestal bone loss (DIB diff).

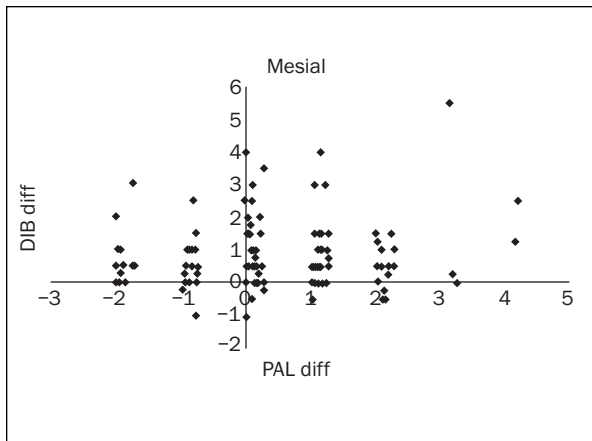


Fig 5a Pearson correlation mesial: $r^2 = .02, P > .05$.

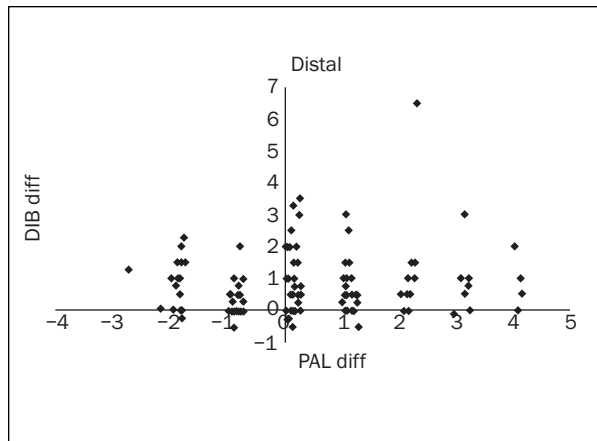


Fig 5b Pearson correlation distal: $r^2 = .01, P > .05$.

appears to be a major reason for implant loss and is often combined with a reduced number of implants for the support of maxillary prostheses. All but 1 implant lost in the present study had a length of 6, 8, or 10 mm. However, 70% of the implants placed were these lengths. Comparison of survival rates with data available from the literature is difficult since the definitions of success, failure, and survival are unclear or vary.³¹ There is a lack of consensus in the application of criteria for success. There are also differences in the way the percentages are calculated for dropouts, sleeping or lost implants, and early failures. The present study used a life table analysis and reports a rather favorable survival rate, within the limits of a still small number of implants and a short evaluation period. According to the criteria established for ITI implants,^{32,33} which do not claim individual annual measurements of crestal bone as an essential criterion for success,³⁴ but rather absence of peri-implant translucency on radiographs, 164 implants could be considered successful.

Well-established treatment concepts for maxillary overdentures that are critically evaluated on a long-term basis are still needed. However, suggestions for planning and clinical procedures were made.^{23,31,35,36} Accordingly, in the present study all patients were treatment-planned for overdentures, with an average of 4 implants per overdenture. In contrast, another study reported that 7 or more implants were used to support the overdenture.³⁶ Most implants were placed in an anterior location, which allowed for a standard surgical protocol, ie, no bone grafting or sinus floor elevation was performed. These are procedures that may complicate treatment and increase the risk for failures. A randomized clinical trial showed that maxillary implants in grafted bone were lost more frequently than in normal jawbone.³⁷ One patient in the present study experienced early and late implant failures, which resulted in the loss of all implants. For this patient, some risk factors could be identified: apparently adverse conditions of professional life that led to psychologic stress, which included occlusal parafunction and a phase of heavy smoking. Various studies have been reported on a clustering effect.^{18,19,38} Obviously, subgroups with higher risks exist that have to be identified by applying the concept of a multilevel risk assessment.³⁹ Thus, it is suggested that the patient with multiple implants, not the single implant, should be the measured entity.⁴⁰

The peri-implant parameters provided evidence of good oral hygiene and healthy soft tissues. The PDs increased slightly and some clinical attachment loss was observed. These findings are in accordance with results from other studies.^{13,21,34}

Radiographic records were not kept annually. Therefore, individual annual changes of the crestal bone could not be measured, which would be the most stringent way to report on the peri-implant bone. For those patients with available radiographs, the radiographically measured mean crestal bone loss was statistically significant at mesial and distal sites in all 3 time groups, with an average increase in DIB of 0.7 mm during a mean observation period of 4.1 years. From this observation one may conclude that pronounced crestal bone loss had occurred early, ie, during the initial phase of loading.

The DIB of these maxillary implants increased to a larger extent than was reported in a multicenter study for ITI implants⁴¹ in which all prosthetic indications in partially and completely edentulous patients were included. The findings of the present study corroborate well the results of another study that compared fixed and removable prostheses in the edentulous maxilla.³⁶ In fact, implants in the edentulous maxilla appear to be at a higher risk for loss of crestal bone, even in the presence of healthy soft tissues.⁴² A few implants exhibited advanced bone loss during the initial loading phase, with a subsequent stabilization of the marginal bone at a low level. This occurred in spite of healthy soft tissues. Other implants showed an increased bone density around the implant body in the course of the observation period. In the study by Adell and coworkers,¹ bone loss of 1.3 to 1.5 mm was measured around maxillary implants in the anterior zone, covering a time period from the healing phase through the first year of loading. The findings of the present study seem to be in accordance with these early results, taking into account that some bone was already lost before the loading phase. One study reported that bone loss was pronounced during the healing phase, ie, up to 0.8 mm,²⁷ while a more recent investigation found 1 mm of bone loss during the healing phase for both Brånemark System implants (Nobel Biocare, Göteborg, Sweden) and ITI implants.⁴³ No uniform results are available regarding the effects of preoperative bone resorption, bone quality, and the preoperative duration of edentulousness^{13,44} on marginal bone loss.

Controversy and lack of information have also been noted regarding the role of the peri-implant/mucosal interface and the usefulness of traditional periodontal clinical measurements as predictors for peri-implant bone level changes.⁴⁵ While repeated measurements of the PAL appeared to be a good indicator for the location of the crestal bone level around mandibular implants,⁴⁶ other studies did not find a correlation between these.^{47,48} The Pearson correlation coefficient was low in the present

study. In fact, probing could not be easily performed around many implants, which had a tight collar of healthy soft tissue, rendering the procedure painful and traumatic for the patients.

CONCLUSIONS

On the basis of well-established treatment concepts, the predictability of overdenture treatment in the maxilla has improved. The survival rate of maxillary implants supporting an overdenture can be enhanced with planned treatment. Some pronounced marginal bone loss around the implants was observed in this patient population.

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