A 3-Year Prospective Multicenter Follow-up Report on the Immediate and Delayed-Immediate Placement of Implants

Ueli Grunder, DDS*/Giovanni Polizzi, DDS, MD**/Ronnie Goené, DDS***/
Naoki Hatano, DDS****/Patrick Henry, BDSc, MSD*****/
William J. Jackson, MDS******/Kunio Kawamura, DDS*******/
Steffen Köhler, DDS, MS********/Franck Renouard, DDS*********/
Ruben Rosenberg, DDS**********/Gilbert Triplett, DDS, PhD**********/
Marvin Werbitt, DDS, MScD**********/Berit Lithner**********

A total of 264 implants was placed in 143 patients using different immediate or delayed-immediate implant placement techniques in 12 different centers participating in a prospective multicenter study. The reason for tooth extraction was evaluated; bone quality and quantity were classified; socket depths were registered; and data on implant type, size, and position were collected. One hundred thirty-nine suprastructures were placed on 228 implants in 126 patients. A follow-up evaluation was done on 125 patients after 1 year of loading and on 107 patients after 3 years of loading. Clinical parameters (bleeding or not bleeding, pocket depth, and implant mobility) were evaluated after 1 and 3 years, and the marginal bone level after 1 year of loading was measured on radiographs. Clinical comparisons were performed to evaluate implant loss in relation to implant type, size, position, bone quality and quantity, socket depth, reason for tooth extraction, and placement method. In addition, life table analysis was done for cumulative implant survival rates. There was no clinical difference with respect to socket depth or when comparing the different placement methods. A higher failure rate was found for short implants in the posterior region of the maxilla and when periodontitis was cited as a reason for tooth extraction. Mean marginal bone resorption from the time of loading to the 1-year follow-up was 0.8 mm in the maxilla and 0.5 mm in the mandible. Over a period of 3 years, the implant survival rate was 92.4% in the maxilla and 94.7% in the mandible.
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*Private Practice, Zollikon-Zürich, Switzerland.
**Private Practice, Verona, Italy.
***Kliniek voor Parodontologie, Amsterdam, The Netherlands.
****Hatano Dental Clinic, Saitama, Japan.
*****The Brånemark Center, Perth, Australia.
******Private Practice, North Sydney, Australia.
*******Osseointegration Implant Center, Osaka, Japan.
********Mund, Kiefer-Gesichtschirurgie, Berlin, Germany.
*********Private Practice, Paris, France.
**********B.O.C., Santiago de Chile, Chile.
***********Professor and Chairman, Department of Oral and Maxillofacial Surgery and Pharmacology, Baylor College of Dentistry, Dallas, Texas.
************Department of Periodontics, McGill University, Montréal, Canada.
*************Clinical Research Associate, Nobel Biocare AB, Göteborg, Sweden.

Placing an implant immediately or a short time after tooth extraction offers several advantages for the patient as well as for the clinician, including shorter treatment time, less bone resorption, fewer surgical sessions, easier definition of the implant position, and perhaps better opportunities for osseointegration because of the healing potential of the fresh extraction site.[1–3] Therefore, these methods of implant placement have increasingly become the procedures of choice. A number of animal studies have reported that successful osseointegration is possible when implants are placed

Reprint requests: Dr Ueli Grunder, Dufourstrasse 7A, Zollikon-Zürich, Switzerland. Fax: +41-1-391-89-20.

Table 1 Number of Implants Placed According to Placement Method Used

	Immediate placement				After soft tissue healing			
	1	1, 3	1, 4	1, 3, 4	2	2, 3	2, 4	2, 3, 4
Maxillae	71	45	6	8	23	10	1	1
Mandibles	75	9	1	2	11	0	0	1

Placement methods: 1 = immediate placement; 2 = soft tissue healing for 3 to 5 weeks before placement; 3 = membranes used; 4 = freeze-dried bone, bone grafts, or collagen used.

immediately after tooth extraction, with or without the help of guided bone regeneration procedures.[4–9] Different human studies have shown that the immediate implant placement method can provide a success rate for osseointegration similar to that obtained for the placement of implants into ossified extraction sites, namely over 90%.[10–15] Long-term data for immediate implants are available for up to 3 years.[16]

The purpose of this prospective multicenter study was to evaluate the long-term success of the immediate and delayed-immediate placement of implants with respect to implant type and size, bone quality and quantity, implant position, socket depth, reason for tooth extraction, and placement methods.

Materials and Methods

A total of 143 patients, 75 females and 68 males with an average age of 47 and 40 years, respectively, were treated in 12 different centers with immediate or delayed-immediate implant placement. Since different surgical techniques were used, the patients were divided into subgroups, depending on what type of direct placement technique was used.

The methods were:

1. The implant was placed immediately after tooth extraction (immediate placement). There was no extra soft tissue healing period. No membranes were used.
2. The implant was placed after a 3- to 5-week healing period (delayed-immediate placement). No membranes were used.
3. Membranes were placed over the extraction site.
4. Freeze-dried bone, bone grafts, or collagen were used.
5. Combination of the above.

Two hundred sixty-four implants (Nobel Biocare AB, Göteborg, Sweden) were placed (165 in the maxilla and 99 in the mandible) in 105 maxillae and 43 mandibles between January 1991 and June 1992 with one of the direct placement methods. Method 1 was used for 146 implants (71 in the maxilla, 75 in the mandible); method 2 was used for 34 implants (23 in the maxilla, 11 in the mandible); method 3 was used for 64 implants, 54 in combination with method 1 (45 in the maxilla, 9 in the mandible) and 10 in combination with method 2 (all in maxillae); method 4 was used for 8 implants, 7 in combination with method 1 (6 in the maxilla, 1 in the mandible) and 1 in combination with method 2 (in the maxilla); and a combination of the methods (method 5) was used for 12 implants, 10 in combination with method 1 (8 in the maxilla, 2 in the mandible) and 2 in combination with method 2 (1 in the maxilla, 1 in the mandible) (Table 1).

The reason for tooth extraction was recorded. Bone quality and quantity were classified according to Lekholm and Zarb.[17] Socket depths were recorded, and data on the implant type, size, and position were collected.

One hundred thirty-nine suprastructures (101 in maxillae, 38 in mandibles) were placed in 126 patients. These were 76 single-tooth replacements (66 in maxillae, 10 in mandibles), 40 partial restorations (22 in maxillae, 18 in mandibles) and 23 complete-arch prostheses (13 in maxillae, 10 in mandibles). In some patients with partial and complete prostheses, both immediate placement and placement according to the standard Brånemark system protocol were used.

A follow-up evaluation was done on 125 patients after 1 year of loading and on 107 patients after 3 years of loading. Clinical parameters (bleeding or no bleeding, pocket depth, and implant mobility) were evaluated after 1 and 3 years. Marginal bone levels were recorded at the time of prosthesis connection and at the 1-year follow-up, based on measurements made from periapical radiographs that were examined by an independent radiologist. All complications were checked and reported. A successful treatment (according to Albrektsson et al[18]) is defined as a

Table 2 Number of Patient Withdrawals by Reason for Withdrawal

	Reasons for withdrawal						
Time	Deceased	Moved	Implant failure	Poor compliance	Other	Unknown	Total
Abutment connection	1	1	2	7	1	1	13
Prostheses placement	0	0	1	1	1	1	4
1 year	0	0	1	0	0	0	1
3 years	0	8	1	5	0	4	18
Total	1	9	5	13	2	6	36

Table 3 Implant Losses in Relation to Bone Quality and Bone Quantity

	Bone quality					Bone quantity					
	1	2	3	4	Unknown	A	B	C	D	E	Unknown
Maxillae											
Placed	0	42	117	4	2	72	65	25	0	2	1
Lost	—	2 (4.8%)	10 (8.5%)	0	0	6 (8.3%)	4 (6.2%)	2 (8.0%)	—	0	0
Mandibles											
Placed	0	44	48	6	1	58	29	4	1	0	7
Lost	—	1 (2.3%)	4 (8.3%)	0	0	4 (6.9%)	0	0	0	—	1 (14.3%)

stable implant without any pathologic findings. Since the fact that no radiographs were taken at the 3-year follow-up, and the suprastructures were not removed to check individual implant stability, this article can report only the survival rate of implants. At the subsequent 5-year follow-up, a radiographic examination will be performed, along with an individual implant stability test.

Cox regression analysis was used to evaluate the influence of bone quality, bone quantity, reason for tooth loss, implant type, location (maxilla or mandible), and method for placement on implant failure. When comparing the failure rates between different implant types, reason for tooth loss, methods for placement, and different implant positions, the chi-square test with Yates' correction was used. One implant in each patient has been used for the statistical analysis to avoid dependence. The implants have been randomized by using a table of random numbers.[19] Life table analyses were used to calculate cumulative survival rates for the implants.

Results

Patients Lost to Follow-up. There were 143 patients included in the study. At the time of abutment connection, 13 patients had withdrawn, followed by another 4 at the time of prosthesis placement. At the 1- and 3-year follow-ups, 1 and 18 patients withdrew, respectively. The reasons for patient withdrawals are given in Table 2. All implant failures that occurred before the patients withdrew are included in the total number of failed implants.

Implant Loss. Ten implants of the 264 placed failed before prosthetic treatment (7 in maxillae and 3 in mandibles). Since 26 implants (16 in maxillae and 10 in mandibles) were withdrawn before loading, 228 implants were loaded. During the first year of loading, another 2 implants failed (1 in the maxilla, 1 in the mandible). At the 3-year follow-up, another 4 implants failed in the maxillae, one in the mandible. Three of 4 maxillary implants failed in a patient who had lost 1 implant at the time of prosthesis placement. Thirteen patients lost 1 implant, and 1 patient lost 4 implants.

Implant Loss in Relation to Implant Type and Size. There was no clinical difference between the failure rate of the standard implants (7.2%) compared to the failure rate of the self-tapping implants (5.2%). Four of 5 implants having a length of 7 mm failed. No clinical difference was found for the failure rate of implants that were between 10 and 20 mm long.

Implant Loss in Relation to Bone Quality and Quantity. More failures appeared in Type 3 bone quality than in Type 2 bone quality (8.5% versus 4.8% in the maxilla and 8.3% versus 2.3% in the mandible, respectively) (Table 3). None of the 10

Table 4 Implant Failures in Relation to Position

	Maxilla				Mandible					
	Anterior		Posterior		Anterior		Posterior		Total	
Implant size	Placed	Lost	Placed	Lost	Placed	Lost	Placed	Lost	Placed	Lost
3.75-mm-diameter										
7 mm long	0	0	3	3	0	0	2	1	5	4
10 mm long	3	0	3	0	0	0	19	1	25	1
13 mm long	21	2	5	0	3	0	8	0	37	2
15 mm long	24	1	1	0	14	2	7	1	46	4
18 mm long	10	1	0	0	11	0	7	0	28	1
20 mm long	8	0	0	0	10	0	5	0	23	0
4.00-mm-diameter										
10 mm long	0	0	0	0	0	0	1	0	1	0
Self-tapping										
10 mm long	2	0	10	1	0	0	2	0	14	1
13 mm long	14	0	11	0	1	0	5	0	31	0
15 mm long	29	3	7	1	0	0	1	0	37	4
18 mm long	9	0	4	0	0	0	0	0	13	0
5.00-mm-diameter										
10 mm long	0	0	1	0	0	0	0	0	1	0
12 mm long	0	0	0	0	0	0	1	0	1	0
3.00-mm-diameter										
13 mm long	0	0	0	0	2	0	0	0	2	0
Total	120	7	45	5	41	2	58	3	264	17
Failure rates	5.8%		11.1%		4.9%		5.2%		6.4%	

implants (4 in the maxilla, 6 in the mandible) placed in Type 4 bone quality failed. There were no implants placed in Type 1 bone quality.

In relation to bone quantity of Types A, B, and C, no clinical difference in the failure rate for maxillary implants was seen (8.3% in Type A bone, 6.2% in Type B bone, and 8.0% in Type C bone). No implants were placed in maxillae with Type D bone. Only 2 implants were placed in maxillae with Type E bone, and neither of them was lost. In the mandibles, a failure rate of 6.9% was found for Type A bone (3 implants), and 1 other failure occurred in a site where bone quantity was not recorded. No failure occurred in Types B, C, and D bone. No implant was placed in mandibles with Type E bone.

Implant Loss in Relation to Implant Position. The failure rate for implants placed in posterior maxillae was higher than that for implants in the anterior region (11.1% versus 5.8%) (Table 4). Three of 5 implants that were lost from posterior maxillae had a length of 7 mm. In the mandibles, the difference in failure rates was smaller (5.2% for the posterior versus 4.9% for the anterior regions).

Implant Loss in Relation to Socket Depth. There was no clinical difference of the implant failure rate when compared to the socket depth in which the implants had been placed.

Implant Loss in Relation to Reason for Tooth Extraction. More implants were lost if the reason for tooth extraction was periodontitis (10.2%) when compared to trauma (0%), root fracture (0%), periapical inflammation (0%), and caries (5.0%) (Table 5). If teeth were extracted for a combination of reasons, in 4 of 6 failures periodontitis was one of the reasons for tooth extraction. Only 3 of the 14 patients having an implant failure had no history of periodontitis before tooth extraction.

Implant Loss in Relation to Placement Method. Of the 10 implants that failed before prosthetic treatment, 5 had been immediately placed (method 1), 2 had been placed after a healing period (method 2), and 3 had been immediately placed with a membrane (methods 1 and 3). Of the 2 implants that failed during the first year after loading, 1 was placed according to method 1 and 1 according to method 2. Of the 5 implants that failed after between 1 and 3 years of loading, 3 were placed according to method 1, and 2 were placed according to methods 1 and 3. There was no clinical difference in the survival rate between methods 1 and 2.

Gingival Status and Pocket Depths. For all followed patients, the peri-implant situations throughout the first 3 years after prosthetic treatment remained stable (Table 6).

Marginal Bone Level. The mean marginal bone level after 1 year was 1.5 mm in the maxilla and 0.9 mm in the mandible, based on 78% of the implants (Table 7). The mean marginal bone

resorption from the time of loading to the 1-year follow-up was 0.8 mm in the maxilla and 0.5 mm in the mandible, but this difference could be evaluated for only 62% of the implants, because of missing poor-quality radiographs.

Life Table Analysis. The implant survival rate at the time of loading was 95.8% in maxillae and 97.0% in mandibles, and the cumulative implant survival rate after 3 years was 92.4% for maxillae and 94.7% for mandibles (Table 8).

Table 5 Implant Failures with Respect to Reason for Tooth Extraction

Reason for extraction	No. placed	No. lost	Failure rate (%)
Periodontitis	98	10	10.2
Trauma	14	0	
Root fracture	18	0	
Periapical infl	5	0	
Caries	20	1	5.0
Combinations	109	6	5.5
Periodontitis and periapical infl	30	2	6.7
Periodontitis, periapical infl, and caries	17	0	
Trauma and root fracture	12	0	
Periapical infl and caries	6	1	16.7
Periodontitis and caries	6	1	16.7
Root fracture, periapical infl, and caries	4	0	
Periodontitis and root fracture	4	0	
Trauma and periapical infl	3	0	
Root fracture and periapical infl	3	0	
Root fracture and caries	2	0	
Trauma, root fracture, and periapical infl	1	0	
Trauma, periodontitis, and periapical infl	2	0	
Periodontitis, root fracture, and periapical infl	3	1	33.3
Trauma and periodontitis	1	0	
Other	15	1	6.7

Periapical infl = periapical inflammatory changes.

Table 6 Gingival Status and Pocket Depths

	Maxillae			Mandibles		
	Prosthesis connection	1 year	3 years	Prosthesis connection	1 year	3 years
Gingival status						
No bleeding	76%	80%	79%	72%	87%	84%
Bleeding	24%	20%	21%	28%	13%	16%
n	382	489	314	190	226	280
Pocket depths						
< 4 mm	82%	79%	80%	91%	92%	95%
≥ 4 mm	18%	21%	20%	9%	8%	5%
n	428	516	422	312	304	276

Table 7 Marginal Bone Level at the 1-Year Follow-up

	Maxillae		Mandibles	
Bone level (mm)	Mesial (n = 101)	Distal (n = 101)	Mesial (n = 76)	Distal (n = 76)
0	16	16	33	30
0.1 to 0.5	15	9	5	8
0.6 to 1.0	20	29	21	19
1.1 to 2.0	30	23	11	12
> 2	20	24	6	7
Mean ± SD	1.4 ± 1.5	1.6 ± 1.6	0.8 ± 1.0	0.9 ± 1.0

No relationship ($P > .05$) could be found between implant failures and bone quality, bone quantity, reason for tooth loss, implant type, arch location, or method for placement. No significant difference ($P > .05$) could be found when comparing the failure rates between different implant types, reason for tooth loss, methods for placement, and different implant positions. The effect of different bone qualities and quantities, implant length, and socket depths on implant failure have not been evaluated, since the number of sites with different bone quality or quantity, different implant lengths, and different socket depths varied too greatly.

Complications. As previously described, 17 implants were lost. Fistula formation was seen in 8 patients at abutment connection time. Three fistulae were still present at the 1-year follow-up and one at the 3-year follow-up. Soft tissue penetration was also registered for 8 patients at abutment connection time. Two patients had paresthesia at the time of abutment connection, but this had disappeared at the 1-year follow-up. There was no clinical difference in complications between the different placement methods.

Discussion

A cumulative survival rate of 92.4% for maxillae and 94.7% for mandibles after 3 years of loading are similar to survival rates described in other studies that examined delayed or immediate implantation methods.[10,16] Of all failures, 58.8% (17 implants) appeared before loading; 11.8% occurred between 1 month and 1 year of loading, and 29% occurred between 1 and 3 years of loading. This very high number of failures after loading leads to the speculation that the healing time of 6 months in the maxilla and 3 to 4 months in the mandible should possibly be lengthened when any immediate implantation method is used.

The failure rate of 80% for 7-mm implants confirms the results of various other studies,[20–22] as well as the higher failure rates for implants in the posterior maxillae.[23,24] However, it is very difficult to obtain good primary stability in a fresh extraction socket in the posterior maxilla with 7-mm implants that are 3.75 or 4 mm in diameter, as were those used in this study. Implants with wider diameters could perhaps have better prognoses.

One of the outcomes of this study is the clinical correlation of a higher failure rate when periodontitis is a reason for tooth extraction. In 14 of the 17 patients who lost an implant, periodontitis was the reason or one of the reasons why a tooth had to be extracted. Similar findings were reported by Rosenquist and Grenthe.[15] The vast majority of implants (78.4%) placed in this study were associated with a history of previous local attachment loss resulting from periodontal disease, and therefore it might be difficult to assume a causal association between implant failure and a previous history of periodontal disease. The depth of the extraction socket also does not appear to influence the survival rate of implants.

Comparing the results of the different methods used in this study, there was no difference, regardless of whether an implant was placed immediately after tooth extraction or after allowing several weeks of soft tissue healing, if no membranes were used. These results correspond well with the results published by Mensdorff-Pouilly et al.[12] Nevertheless, within the limits of this study, it was not possible to compare all the different methods used in this study. For example, it is not known whether there is a difference in the prognosis for implants that were placed immediately or for implants that were delayed slightly, both in combination with a membrane technique.

Table 8 Life Table Analysis

	Maxillary implants						Mandibular implants					
Time	No. of implants	Failed	Withdrawn	Missing	Time not passed	CSR	No. of implants	Failed	Withdrawn	Missing	Time not passed	CSR
Placement to loading	165	7	16	0	0	95.8%	99	3	10	0	0	97.0%
Loading to 1 y	142	1	0	0	0	95.1%	86	1	0	0	0	95.8%
1 to 3 y	141	4*	18	0	1	92.4%	85	1	7	0	0	94.7%
3 to 5 y	119	0	0	0	101	—	78	0	0	0	61	—
5 y	18	—	—	—	—	—	17	—	—	—	—	—

*One of these implants fractured.
CSR = cumulative survival rate.

Conclusion

This study demonstrated that Brånemark implants placed according to an immediate or a delayed-immediate method can be successful over a period of 3 years. The success rate of 92.4% for maxillae and 94.7% for mandibles is comparable with the outcomes of other studies. The risk factor of failures in this study are similar to those described in other studies, ie, short implants in the posterior region of the maxilla failed more often. Additional studies are needed to evaluate the effect of other specific surgical protocols for immediate implant placement.

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