

Implant Treatment of Patients with Edentulous Jaws: A 20-Year Follow-Up

Per Åstrand, DDS, PhD;* Jan Ahlqvist, DDS, PhD;† Johan Gunne, DDS, PhD;‡ Hans Nilson, DDS‡

ABSTRACT

Background: Implant-supported prostheses are today often used in rehabilitation of partially or totally edentulous patients. Both patients and the dental profession often regard implant treatment as successful in a life perspective. Therefore, studies with a long-term follow-up are important.

Purpose: The aim was to investigate the outcome of implant treatment with fixed prostheses in edentulous jaws after 20 years, with special reference to survival rate of implants and prostheses and frequency of peri-implantitis.

Materials and Methods: The patient material was a group of patients treated in the early 1980s. The original patient group comprised the first 48 consecutive patients treated with implant-supported prostheses at Umeå University. All patients were edentulous in one or two jaws. The patients had a mean age at the implant insertion of 54.3 years (range 40–74). At the planning of this study 20 years after treatment, 19 of the 48 patients were found to be deceased. Of the 29 patients still alive, 21 patients with altogether 23 implant-supported prostheses could be examined clinically and radiographically. All patients were treated ad modum Brånemark® (Nobel Biocare AB, Göteborg, Sweden) with a two-stage surgical procedure. The implants had a turned surface. Abutment connections were performed 3 to 4 months after fixture insertion in the mandible, and after a minimum of 6 months in the maxilla. The prostheses were fabricated with a framework of gold alloy and acrylic artificial teeth.

Results: The 21 patients (with 23 implant prostheses) examined had at the time of treatment got 123 implants (27 in the upper jaw and 96 in the lower jaw) inserted. Only one of these implants had been lost (about 2 years after loading) giving a survival rate of 99.2%. Very small changes occurred in the marginal bone level. Between the 1 and 20-year examinations, the mean bone loss was 0.53 mm and the mean bone level at the final examination was 2.33 mm below the reference point.

Conclusions: This follow-up over two decades of implant-supported prostheses demonstrates a very good prognosis for the treatment performed. The frequencies of peri-implantitis, implant failures, or other complications were very small, and the original treatment concept with a two-stage surgery and a turned surface of the implants will obviously give very good results.

KEY WORDS: Brånemark implants, edentulous jaws, fixed complete prostheses, long-term follow-up

Implant-supported prostheses are today often used in rehabilitation of partially or totally edentulous patients. The outcome of these procedures has been described in several reviews.^{1–4} The results of implant

treatment have mostly been very good with survival rates of 85 to 99%.

With the exception of the early reports^{5,6} from the Brånemark group in Göteborg, few longitudinal studies^{7–10} with a follow-up of 10 years or more have been reported. A systematic review of biological and technical complications reported in longitudinal studies with an observation time of at least 5 years has been published by Berglundh and colleagues.³ They found only a few reports with observation periods of more than 10 years. Despite high survival or success rates, implant-supported prostheses are afflicted with both biological and technical complications. Several reports have demonstrated cases of peri-implantitis possibly affecting long-term survival rate.^{11–13} Progressive bone

*Department of Oral and Maxillofacial Surgery, University Hospital, Linköping Sweden; †Department of Oral and Maxillofacial Radiology, Umeå University, Umeå, Sweden; ‡Department of Prosthetic Dentistry, Umeå University, Umeå, Sweden

Reprint requests: Professor Johan Gunne, Department of Prosthetic Dentistry, Umeå University, SE-901 87 Umeå, Sweden; e-mail: johan.gunne@odont.umu.se

© 2008, Copyright the Authors

Journal Compilation © 2008, Wiley Periodicals, Inc.

DOI 10.1111/j.1708-8208.2007.00081.x

loss has been reported to affect 28% of the patients 5 years after implant treatment,¹⁴ and peri-implantitis has been reported by Roos-Janåker and colleagues¹³ to occur in 16% of the patients and at 6.6% of the implants.

To further elucidate the long-term outcome of the treatments and the occurrence of peri-implantitis, more studies with observation periods of 10 to 20 years are desirable.⁴ Umeå University was one of the Swedish centers outside Göteborg where the use of osseointegrated implants ad modum Brånemark started in the early 1980s. The 2-year results of the first 50 implant-supported prostheses at this center were reported in 1990,¹⁵ and this patient group was considered suitable for a 20-year follow-up.

The aim of the study was to investigate the outcome of implant treatment with fixed prostheses in edentulous jaws after 20 years, with special reference to survival rates of implants and prostheses and frequency of peri-implantitis.

MATERIALS AND METHODS

Patients

The patient material was those patients reported in 1990 who were still available for clinical and radiographic examinations. The original patient group comprised the first 48 consecutive patients treated with implant-supported prostheses and without need of bone graft procedures. All implants were inserted in edentulous jaws. The patients had a mean age at the implant insertion of 54.3 years (range 40–74).

Two of these 48 patients had implants in both upper and lower jaws resulting in 50 treated jaws (17 maxillary and 33 mandibular). At the planning of this study, 19 of the 48 patients (with 102 implants) were found to be deceased. Of the 29 patients still alive, 21 patients with altogether 23 implant prostheses have attended the study. Eight patients (with 44 implants) were not able to attend the examination because of age and/or sickness. The age and sex distributions of the patients in connection with the 20-year follow-up are shown in Table 1. The patients had observation periods between 20 and 24 years. However, the follow-up described in this paper is called a 20-year examination. At the 20-year examination, most patients had some kind of disease because of their high age. They had, for example, diabetes, hypertension, and joint diseases. Some patients had steroid or antidepressant drugs. Seven of the patients were smokers.

TABLE 1 Age and Sex Distribution of the Patients at the 20-year Examination

	Age				Total
	61–70	71–80	81–90	91–100	
Male	2	2	3	—	7
Female	9	1	3	1	14
Total	11	3	6	1	21

Of the 23 prostheses, six were maxillary prostheses and 17 were mandibular prostheses. The occluding jaws of the maxillary prostheses were complete dentures (two), implant-supported prostheses (two), or natural dentition (two). The occluding jaws of the mandibular prostheses were complete dentures (15) or implant-supported prostheses (two). The number of implants inserted was 123 (96 in the mandible and 27 in the maxilla). The number of implants supporting the prostheses varied from four to six (Table 2).

Surgical and Prosthetic Procedures

The surgical and prosthetic procedures were described earlier.¹⁵ All patients were treated ad modum Brånemark® (Nobel Biocare AB, Göteborg, Sweden) with a two-stage surgical procedure. Brånemark implants with a turned surface were used.

Abutment connections were performed 3 to 4 months after fixture insertion in the mandible, and after a minimum of 6 months in the maxilla. Straight cylindrical abutments were used in all cases.

The prostheses were fabricated with a framework of gold alloy and acrylic artificial teeth.

Follow-Up

In the report from 1990, the stability of prostheses and inflammation of peri-implant tissues were recorded. A

TABLE 2 Number of Prostheses with Different Number of Supporting Implants

Number of supporting implants	Number of restorations maxilla	Number of restorations mandible	Total
4	4	—	4
5	1	6	7
6	1	11	12
Total	6	17	23

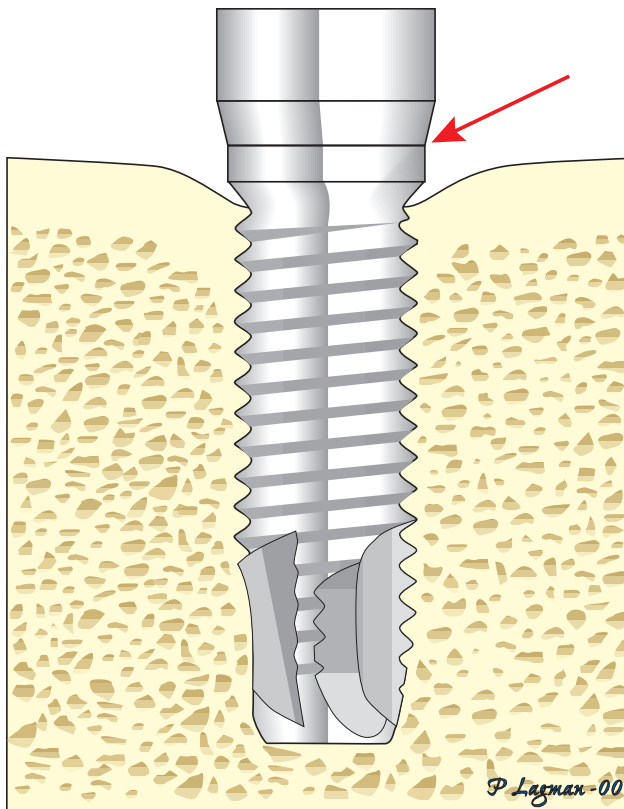


Figure 1 The measurements of the marginal bone level were performed in relation to a reference point, the fixture/abutment junction, at the implant.

radiographic examination was made when the implants were loaded (BL, baseline) and at the 1- and 2-year examinations.

Clinical Examination. In the present investigation (20–24 years after treatment), the following clinical records were made: (1) stability of the prostheses (removal of the prostheses only at sign of loss of osseointegration or mobility of the bridge), (2) pocket depth (four surfaces), (3) hyperplasia of peri-implant mucosa and other soft tissue lesions (buccally and lingually), (4) plaque (four surfaces), and (5) bleeding on probing (four surfaces).

Radiographic Examination. The marginal bone level was evaluated by intraoral radiographic examinations performed with parallel technique. In all examinations, Kodak Ectaspeed® film was used. The bone level was measured in the radiographs and defined as the distance from a reference point at the implant (fixture/abutment junction; Figure 1) to the most coronal point where the marginal bone meets the

implant surface. The measurements were made to the nearest tenth of a millimeter. A loupe with a magnifying factor of $\times 7$ was used, and measurements were made mesially and distally of each implant. The mean value of these measurements was used for the calculations.

The measurements were made independently by two of the investigators (J.A. and J.G.). If there was a discrepancy between the measurements ≤ 0.4 mm, the mean value was used. If the difference was ≥ 0.5 mm, the radiographs were re-examined by both investigators together and consensus sought. The results of the measurements were compared with the measurements made at baseline (loading of the implants) and the 1-year follow-up in connection with the 1990 paper (Figure 2).¹⁵

RESULTS

Implant Survival and Prosthesis Stability

The 21 patients (with 23 implant prostheses) examined had at the time of treatment obtained 123 implants (27 in the upper jaw and 96 in the lower jaw) inserted. Only one of these implants had been lost (2 years and 4 months after loading) giving a survival rate of 99.2%. At the 20-year examination, none of the patients reported pain from the tissues surrounding the implants.

One of the prostheses was found to be mobile. However, after removal of the prosthesis, the implants were found stable and the prosthesis could again be attached to the implants. Two other patients reported of similar mobility of their implant-supported prostheses. Also in those cases, the implants were stable and the prostheses could again be attached to the implants. The bridge stability was after these corrections 100%.

Soft Tissue Reactions

Plaque was found at 22% of the implant surfaces and bleeding on probing at 20%. The number of implants with bleeding at one or more surfaces was 55 (45%).

The mean pocket depth was 3.4 mm. At most implants (83%), it was less than 4 mm and only eight implants had pocket depths > 5 mm (Table 3).

Nine implants (7.4%) had hyperplastic mucosa buccally or lingually. These hyperplasias were concentrated to three patients, but none of the patients had signs of infection.

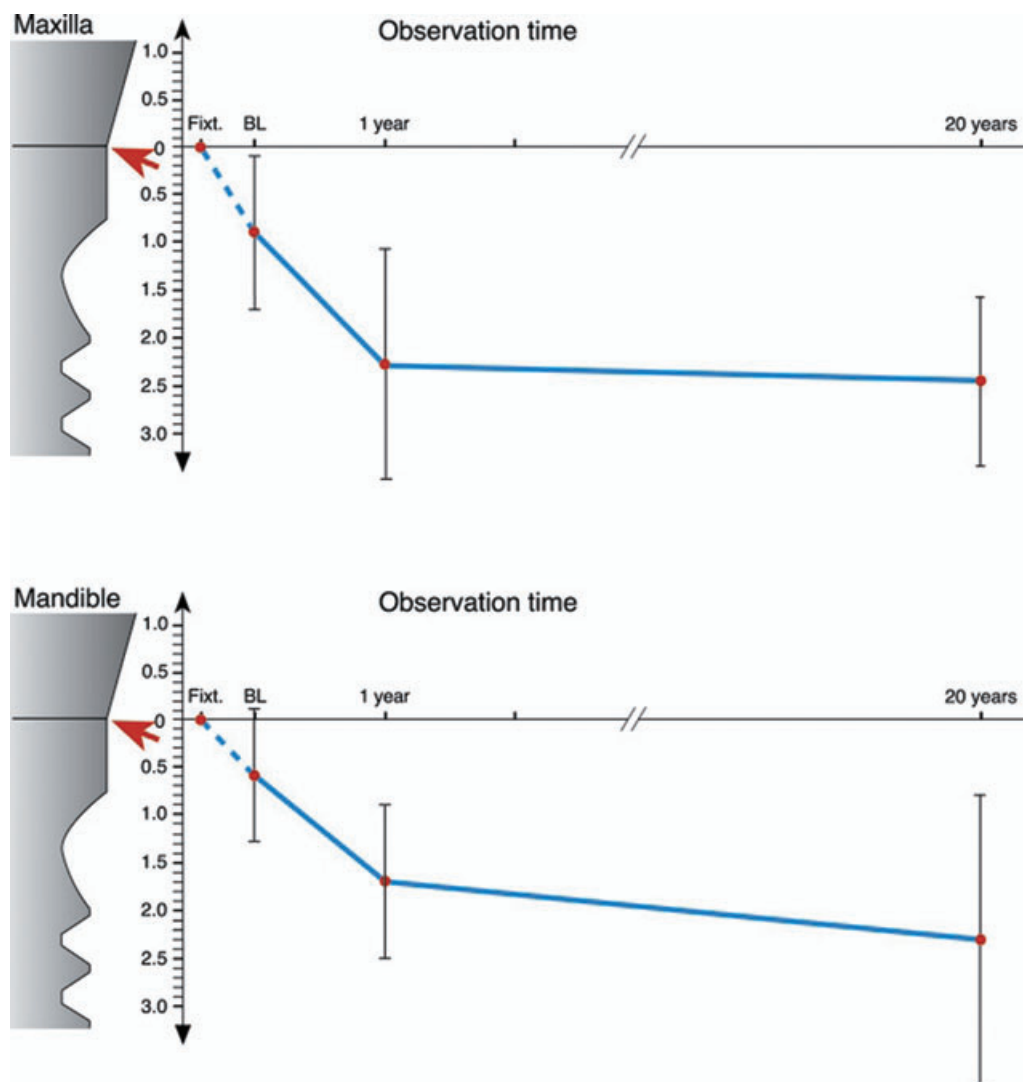


Figure 2 Diagram illustrating the mean marginal bone level in relation to the implants at baseline (loading of the implants, BL), at the 1-year and at the 20-year follow-up. Situation at maxillary implants (top) and at mandibular implants (below).

Marginal Bone Level

Most patients demonstrated a good marginal bone level (Figures 3–5).

At the 20-year examination, the mean bone level was situated 2.33 mm from the reference point with no

significant difference between the upper and lower jaw (Tables 4 and 5). The mean bone level at baseline was situated 0.66 mm from the reference point (0.89 mm in the upper jaw and 0.62 mm in the lower). During the first year, there was a mean bone loss of about 1 mm (mean of

TABLE 3 Number of Implants with Different Pocket Depth Divided Into Maxillary and Mandibular Implants

Pocket depth (mm)	Maxilla		Mandible		Maxilla and mandible	
≤3	6	23%	30	32%	36	30%
3.1–4.0	11	42%	54	57%	65	53%
4.1–5.0	3	12%	9	9%	12	10%
5.1–6.0	6	23%	2	2%	8	7%
>6	—	—	—	—	—	—

Pocket depth was measured at 121 of the 122 surviving implants.

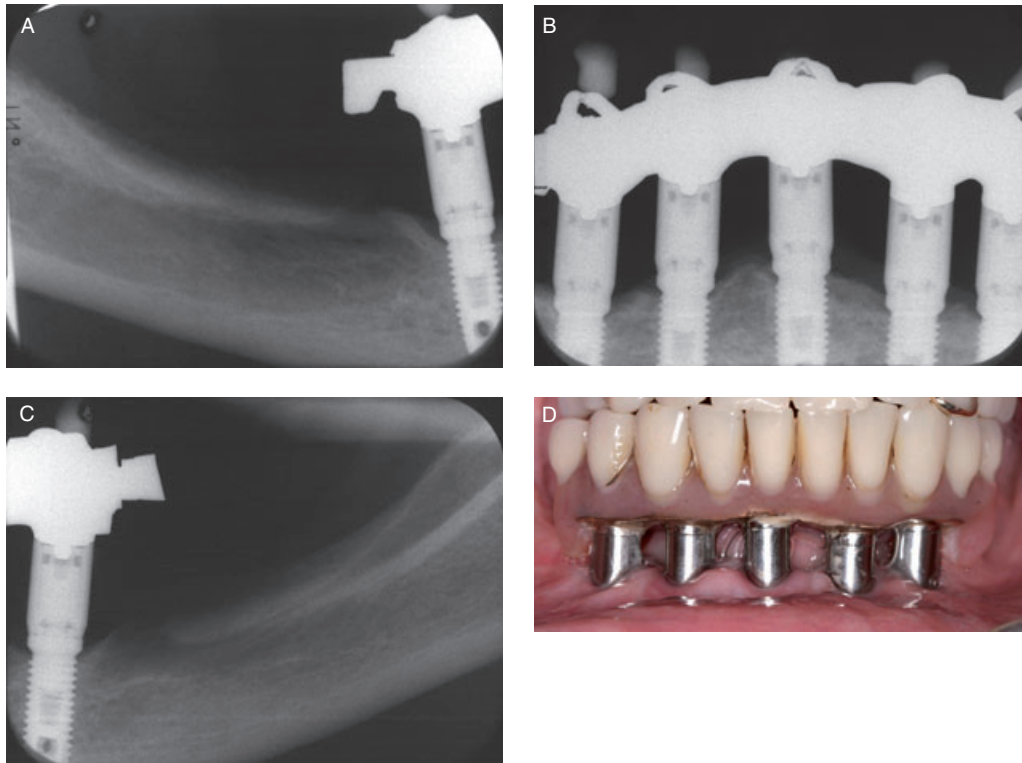


Figure 3 Sixty-five-year-old woman, who at the age of 45 was treated with five mandibular implants. Radiographs demonstrating good bony support of the implants (A–C) and the clinical situation (D) 20 years after treatment.

upper and lower jaw 1.21 mm, see Table 5). Between the first-year examination and the 20-year follow-up, there was only small changes of the marginal bone level. The mean change was -0.53 ± 0.13 mm (maxillary and mandibular implants). Most implants (78%) had during this period a bone loss ≤ 1 mm and only 6% of the implants had a bone loss ≥ 3 mm (Table 6).

During the entire follow-up period (baseline to 20 years), there was a mean bone loss of 1.72 mm. Most implants (89%) had a bone loss of ≤ 3 mm and the frequency of implants with bone loss > 3 mm was 11% (see Table 6).

At the examination of the peri-implant bone, craterform bone losses were found at five implants. These findings will be discussed as follows.

Peri-implantitis and Other Complications

Four patients with five implants had a crater form or beaker-like type of bone loss (Figure 6). Three of these implants had also a bleeding on probing, which may constitute the diagnose of peri-implantitis. With a total of 123 implants, the prevalence of peri-implantitis may be calculated to 2.4%.

TABLE 4 Bone Level Relative to the Reference Point at Baseline, After 1 Year and After 20 Years

	Baseline	1 Year	20 Years
Upper jaw	0.89 ± 0.20 $n = 17$	2.31 ± 0.26 $n = 21$	2.45 ± 0.19 $n = 24$
Lower jaw	0.62 ± 0.08 $n = 84$	1.72 ± 0.09 $n = 86$	2.31 ± 0.16 $n = 92$
Upper and lower jaw	0.66 ± 0.07 $n = 101$	1.84 ± 0.09 $n = 107$	2.33 ± 0.13 $n = 116$

Mean \pm SEM and number of observations.

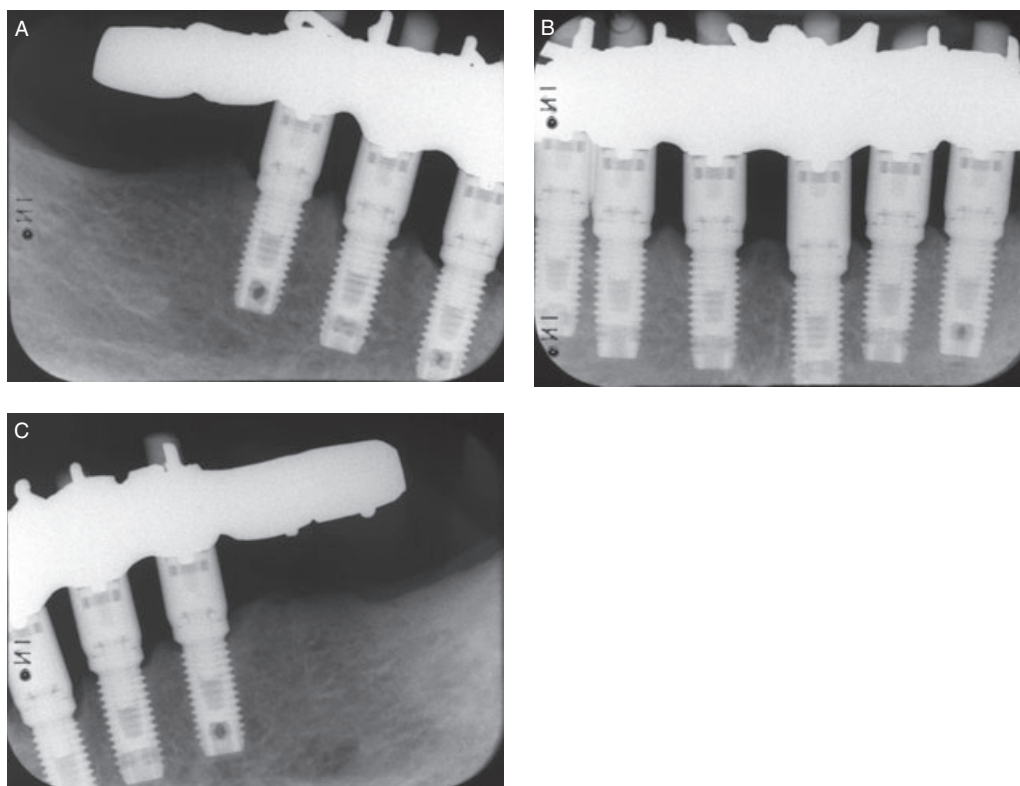


Figure 4 Eighty-three-year-old man who at the age of 59 was treated with six mandibular implants. Radiographs 24 years after treatment demonstrate good marginal bone level.

One patient had threads exposed buccally at five of the six implants. The mean pocket depth of those implants was 3.4 mm.

As described earlier, one patient had a mobile prosthesis and two patients had earlier reported the same complication. However, in all cases, the mobility was because of loosening of the abutment or bridge screws. The stability of the implants was good and the screws could be tightened.

Extensive wear of the acrylic teeth was found in some patients. In one case, a new prosthesis had been made and in four cases the acrylic teeth had been replaced.

DISCUSSION

Patient Material and Long-term Studies

Both patients and the dental profession often regard implant treatment as successful in a life perspective. Therefore, studies with a follow-up of 20 years or more are important. The group of patients used in this study was treated between 1981 and 1985, and had an observation period of 20 to 24 years. Obviously, such clinical follow-ups are difficult to perform. In treatment of edentulous patients, the mean age is high and consequently some of the patients have deceased after 10 to 20

TABLE 5 Changes in Marginal Bone Level Between Different Examinations

	Baseline to 1 year	1 to 20 Years	Baseline to 20 years
Upper jaw	-1.46 ± 0.34 $n = 11$	-0.16 ± 0.29 $n = 18$	-1.34 ± 0.23 $n = 15$
Lower jaw	-1.17 ± 0.11 $n = 74$	-0.61 ± 0.14 $n = 82$	-1.79 ± 0.18 $n = 80$
Upper and lower jaw	-1.21 ± 0.11 $n = 85$	-0.53 ± 0.13 $n = 100$	-1.72 ± 0.16 $n = 95$

Mean \pm SEM and number of observations. Negative values indicate bone loss.

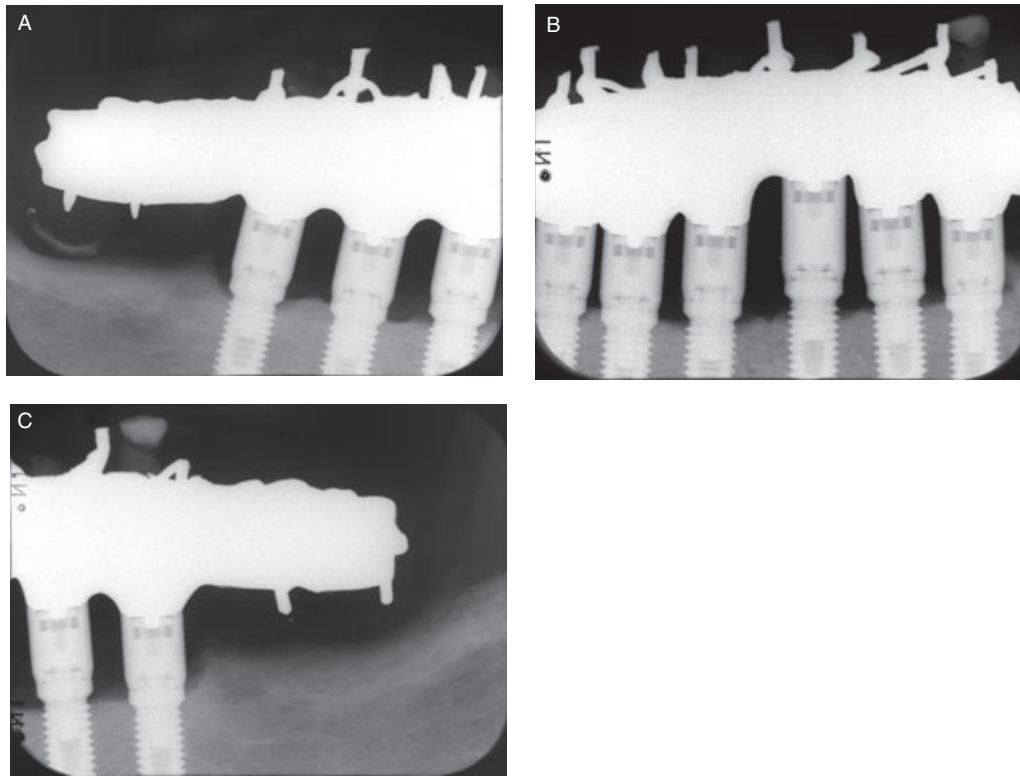


Figure 5 Ninety-year-old woman who at the age of 66 was treated with six mandibular implants. Radiographs 24 years after treatment demonstrate good marginal bone level.

years. Other patients are likely too ill to attend a clinical examination. Taken these facts into consideration, it is not surprisingly that only 21 patients of the original group could be examined. For practical reason and with regard to the age and health of the patients, the supra-constructs were not removed, which means that only survival rates, and not success rates, are reported.

Soft Tissue Reactions

Bleeding on probing was recorded in 20% of the implant surfaces, and bleeding at one or more implants occurred at 45% of the implants. There may be different interpretations of these findings. Ericsson and Lindhe¹⁶ demonstrated in an animal study that probing at implants resulted in a situation where the marginal soft tissues

TABLE 6 Marginal Bone Change Calculated on All Implants (Upper and Lower Jaw)

	Baseline to 1 year		1 to 20 Years		Baseline to 20 years	
Upper and lower jaw	-1.21 ± 0.11 $n = 85$		-0.53 ± 0.13 $n = 100$		-1.72 ± 0.16 $n = 95$	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
0	10	12	46	46	6	6
-0.1 to -1.0	23	27	32	32	29	31
-1.1 to -2.0	41	48	12	12	38	40
-2.1 to -3.0	4	5	4	4	11	12
-3.1 to 4.0	7	8	3	3	2	2
4.1 to 5.0	—	—	1	1	1	1
>-5.0	—	—	2	2	8	8

Mean \pm SEM, number of observations, and frequencies of different size of changes.

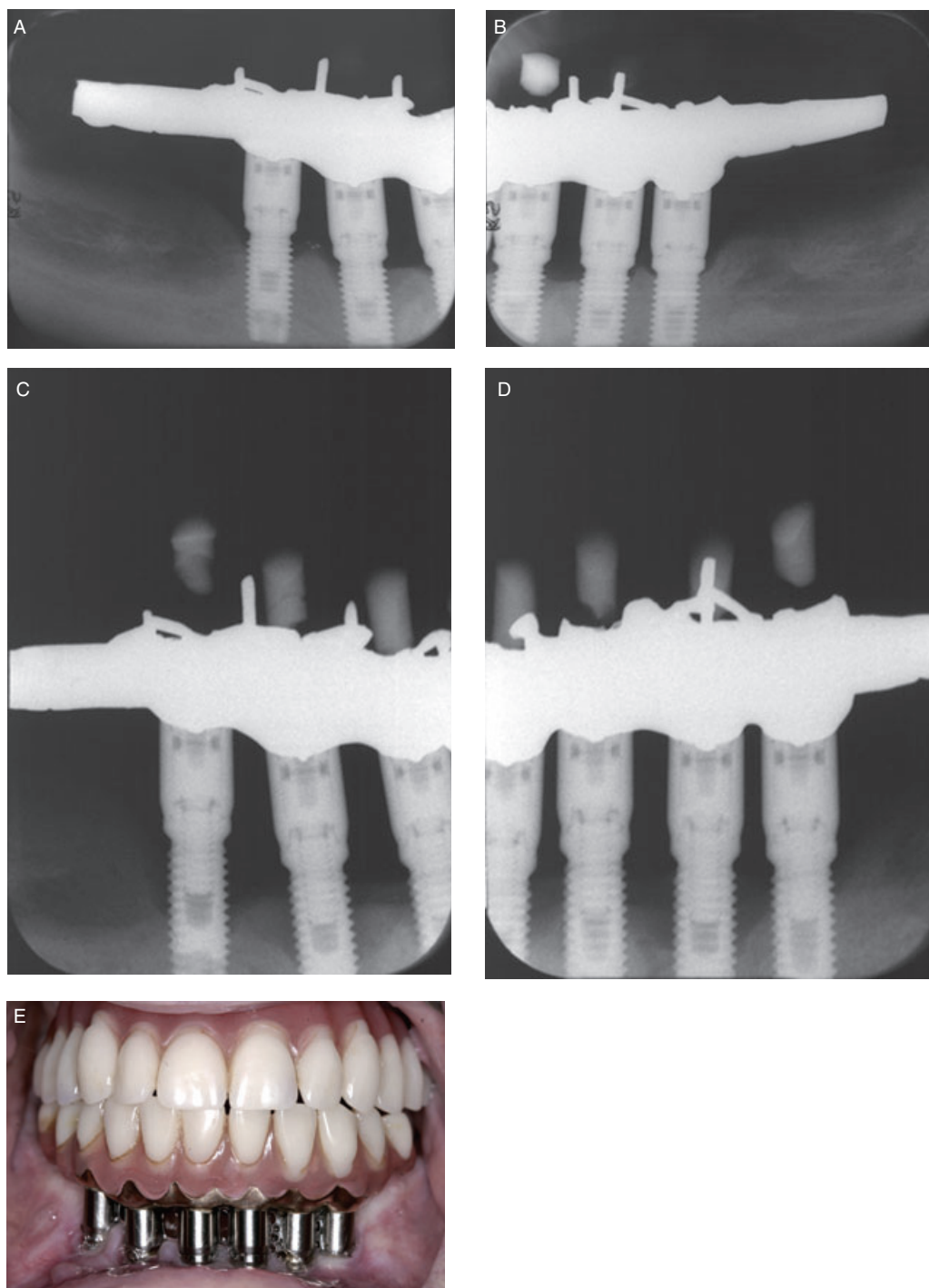


Figure 6 Radiographs of patient number 13 in connection with the treatment 1985 (A and B) and at the 20-year follow-up (C and D). At the implants in positions H2 and V2, craterform bone losses are seen. As both these implants had bleeding on probing at the lingual surface, they were considered as cases of peri-implantitis. In spite of this, the soft tissues looked mainly healthy (E).

were displaced laterally and the probe entered an area of connective tissue. Such damage to the connective tissue may naturally result in bleeding and with a bleeding which is not necessarily associated with inflammation. With regard to this aspect and the fact that in no case any

purulent exudates were recorded, the soft tissues may be considered as mainly healthy.

The value of pocket depth measurements at this follow-up may be questioned, especially as no measurements were performed at baseline. However, the high

number of implants (84%) with pocket depth <4 mm and the few implants with pocket depth of >5 mm indicate still healthy tissues around the implants.

Radiographic Methods

In the presented results, the effect of the radiographic magnification was not compensated for. The reason for this was that we wanted to compare the figures with the study¹⁵ earlier performed at baseline and after 1 year in which compensation for magnification was not used. The average magnification in the examinations performed at the 20-year follow-up was 10%, which can be used to transform the figures into real bone loss if comparisons are to be done with other studies where the magnification has been compensated for.

Number of Implants Used

The number of implants used in the upper and lower jaw may give rise to comments. Most prostheses in the upper jaw were supported by four implants, while six implants had been used in the lower jaw. In the maxilla, the small number was because of a restricted bone volume, and in the lower jaw, six implants was the standard in the early 1980s. Today, most surgeons try to insert more implants in the maxilla, while the number of implants in an edentulous mandible is restricted to four or five.

Survival Rates

In the patient group reported here, there was an implant survival rate of 99.2%. However, this group is part of a greater group including 48 patients treated more than 20 years ago. During this long period of time, several patients were diseased and some had difficulties to attend an examination. However, 72% of those who were not diseased could be examined.

Looking at the original group of 48 patients, the cumulative survival rate was 94.8% (Table 7). This sur-

vival rate after 20 years indicates a very good prognosis for implant-supported prostheses in edentulous jaws. Still better results (98.9%) have been demonstrated in some other reports^{7,8} with 15- to 20-year follow-up. In a long-term follow-up¹⁰ of implants in the edentulous maxillae, a survival rate of 90.6% was demonstrated and in partially edentulous jaws⁹ a cumulative survival rate of 91% was demonstrated after 20 years.

Marginal Bone Level

The main changes of the marginal bone level took place during the first year after prosthetic delivery. Between the 1-year and 20-year examinations, the changes were very small. The mean change was -0.16 ± 0.29 mm in the upper jaw and -0.61 ± 0.14 mm in the lower jaw, which means an annual bone loss of 0.01, respectively, 0.03 mm and that the bone level has reached a steady state. This result may be compared with a study by Lindquist and colleagues⁷ who reported a mean bone loss of 0.05 mm per year.

Peri-implantitis

One of the aims of this study was to investigate whether peri-implantitis will develop after a long observation period. Some authors have reported such complications.^{13,14} Few signs of peri-implantitis were recorded in this study. A craterform or beaker-like bone loss around implants has been discussed as characteristic of peri-implantitis and together with BOP/pus constitute the diagnose of this lesion.¹⁷ In this study, four patients with five implants had this type of bone loss.

However, only three of the implants had a bleeding on probing. With a total of 123 implants, the prevalence of peri-implantitis may with this definition be calculated to 2.4%.

Different definitions of peri-implantitis have, however, been given in the literature.^{3,13,18,19} Berglundh and colleagues³ made a systematic review of the litera-

TABLE 7 Life Table Regarding Implant Survival of the Original Patient Group

Observation period	Number of implants	Failed	Withdrawn	In function	Survival rate within the period (%)	Cumulative survival rate (%)
Insertion to loading	269	4	—	265	98.5	98.5
Loading to 1 year	265	3	—	262	98.9	97.4
1 to 2 Years	262	5	—	257	96.9	95.5
2 to 3 Years	257	2	—	255	99.2	94.8
3 to 20 Years	255	—	132	123	100	94.8

ture, and defined peri-implantitis as probing depth >6 mm in combination with bleeding on probing/suppuration and attachment loss/bone loss of 2.5 mm. They found the prevalence of peri-implantitis reported in different studies to vary from 0 to 14.4%. The lower figures related to edentulous patients and the higher figures to patients with fixed partial denture. In the group of fixed complete dentures, they found an incidence of 1% of peri-implantitis with a range in the different studies of 0 to 3.1%. The different results that have been reported in the literature are obviously depending on the different definitions of peri-implantitis and also on the length of the follow-up period. The results of this study indicate, however, that peri-implantitis is not a great problem in connection with fixed complete prostheses, at least not when implants with a turned surface are used.

Technical Complications

The technical complications observed at the 20-year examination were few and harmless. All the supraconstructions were screw retained, and therefore, the complications were easy to take care of. This advantage will be more important the longer time the prostheses are in function. The frequency of technical complications between the 2-year and the 20-year follow-up may be uncertain, but the comments from the patients supported the statement that the problems had been very few.

CONCLUSION

This report of 23 fixed restorations in 21 edentulous patients followed for two decades demonstrates a very good prognosis for the treatment performed. The frequencies of peri-implantitis, implant failures, or other complications were very small. However, it should be observed that the treatment concept was a two-stage surgery and that implants with a turned surface were used.

ACKNOWLEDGMENT

The authors are grateful to Nobel Biocare AB for financial support of the study.

REFERENCES

- Esposito M, Hirsch J-M, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants (I). Success criteria and epidemiology. *Eur J Oral Sci* 1998; 106:527–551.
- Fiorellini JP, Martuscelli G, Weber HP. Longitudinal studies of implant systems. *Periodontology* 2000 1998; 17:125–131.
- Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. *J Clin Periodontol* 2002; 29(Suppl 3):197–212.
- Pjetursson B, Tan K, Lang N, Brägger U, Egger M, Zwahlen M. A systematic review of the survival and complication rates of fixed partial dentures (FPDs) after an observation period of at least 5 years. I. Implant supported FPDs. *Clin Oral Implants Res* 2004; 15:625–642.
- Adell R, Lekholm U, Rockler B, Brånemark P-I. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int J Oral Surg* 1981; 10:387–416.
- Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of the totally edentulous jaws. *Int J Oral Maxillofac Implants* 1990; 5:347–359.
- Lindquist LW, Carlsson GE, Jemt T. A prospective 15-year follow-up study of mandibular fixed prostheses supported by osseointegrated implants. Clinical results and marginal bone loss. *Clin Oral Implants Res* 1996; 7:329–336.
- Ekelund J-A, Lindquist LW, Carlsson GE, Jemt T. Implant treatment in the edentulous mandible: a prospective study on Brånemark System implants over more than 20 years. *Int J Prosthodont* 2003; 16:602–608.
- Lekholm U, Gröndahl K, Jemt T. Outcome of oral implant treatment in partially edentulous jaws followed 20 years in clinical function. *Clin Implant Dent Relat Res* 2006; 8:178–186.
- Jemt T, Johansson J. Implant treatment in the edentulous maxillae: a 15-year follow-up of 76 consecutive patients provided with fixed prostheses. *Clin Implant Dent Relat Res* 2006; 8:61–69.
- Hellem S, Karlsson U, Almfeldt I, Brunell G, Hamp SE, Åstrand P. Nonsubmerged implants in the treatment of the edentulous lower jaw: a 5-year prospective longitudinal study of ITI hollow screws. *Clin Implant Dent Relat Res* 2001; 3:20–29.
- Åstrand P, Engquist B, Anzén B, et al. A three-year follow-up report of a comparative study of ITI dental implants and Brånemark System implants in the treatment of the partially edentulous maxilla. *Clin Implant Dent Relat Res* 2004; 6:130–141.
- Roos-Janåker AM, Lindahl C, Renvert H, Renvert S. Nine-to fourteen year follow-up of implant treatment. Part II: Presence of peri-implant lesions. *J Clin Periodontol* 2006; 33:290–295.

14. Fransson C, Lekholm U, Jemt T, Berglundh T. Prevalence of subjects with progressive bone loss at implants. *Clin Oral Implants Res* 2005; 16:440–446.
15. Ahlqvist J, Borg K, Gunne J, Nilson H, Olsson M, Åstrand P. Osseointegrated implants in edentulous jaws: a 2-year longitudinal study. *Int J Oral Maxillofac Implants* 1990; 5:155–163.
16. Ericsson I, Lindhe J. Probing at implants and teeth. An experimental study in the dog. *J Clin Periodontol* 1993; 20:623–627.
17. Klinge B, Hultin M, Berglundh T. Peri-implantitis. *The Dent Clin N Am* 2005; 49:661–676.
18. Karoussis IK, Salvi GE, Heitz-Mayfield LJA, Bragger U, Hämerle CH, Lang NP. Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10 year perspective cohort study of the ITI dental implant system. *Clin Oral Implants Res* 2003; 14:329–359.
19. Albrektsson T, Isidor F. Consensus report of session IV. In: Lang NP, Karring T, eds. *Proceedings of the 1st European Workshop on Periodontology*. London, UK: Quintessence, 1994:365–369.