Five-Year Results with Fixed Complete-Arch Mandibular Prostheses Supported by 4 Implants

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This study examined whether it is possible to restore an edentulous mandible with a complete-arch fixed prosthesis retained by only 4 implants without decreasing the survival rate. One hundred nineteen patients received complete-arch mandibular prostheses retained by 4 implants. Most patients were followed for 3 years or more. All patients followed a routine protocol, including annual check-ups and regular radiographic examinations. Twenty-one patients dropped out. Radiographic measurements used the threads of the implants as a basis for comparison. No indication was found that the number of supporting implants could have influenced the observed frequency of technical and surgical complications. Three implants were lost, 2 after 1 year and 1 after 5 years. A statistically significant difference in bone loss between the mesial and distal implants was found. The number of fractured resin teeth in mandibular prostheses was higher when patients had an implant-supported prosthesis in the maxilla. The present study revealed an implant survival rate of 98.6% after 5 years. Therefore, it was concluded that there may not be a need for more than 4 implants to support a fixed mandibular prosthesis, when implants at least 10 mm long can be used. (Int J Oral Maxillofac Implants 2000;15:505–510)

Key words: *dental implants, implant-supported dental prosthesis, mandible*

The original Brånemark concept prescribed 6 endosseous implants to support a fixed prosthesis in a totally edentulous arch.[1] Later clinical research data and clinical experience have provided evidence that a smaller number of implants can be used with good results to support prostheses, provided that the bone quantity permits implants of at least 10 mm in length to be placed.[2–5]

Since 1992 the standard procedure at the Postgraduate Dental Education Center, Örebro, Sweden, has been to place 4 implants between the foramina in the edentulous mandible to support a complete-arch fixed prosthesis. The aim of this study was to report the results of this treatment concept in all patients for whom it was used.

MATERIALS AND METHODS

Between 1985 and the end of 1996, 119 patients were treated with fixed prostheses in the edentulous mandible supported by 4 implants. The protocol called for the placement of implants that were 10 mm or longer with a follow-up of at least 1 year. Of the treated patients, 73 were between 61 and 90 years of age at the time of placement of the implants. The age and gender distribution in the material is shown in Fig 1.

All 476 implants placed in the 119 edentulous mandibles were Brånemark System (Nobel Biocare, Göteborg, Sweden). The lengths and location of the implants are shown in Table 1. Of the implants placed, 10% (49) were 10 mm long or shorter. One hundred three of the frameworks for the fixed prostheses were cast in gold alloy, 15 were milled and laser-welded titanium frameworks, and 1 framework

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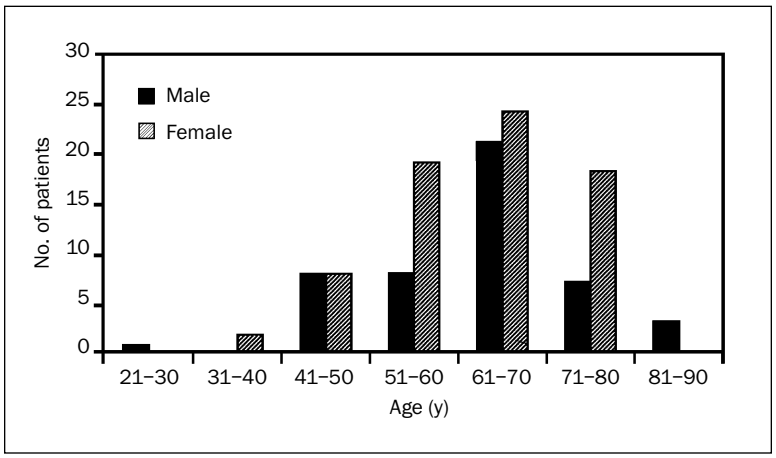

Fig 1 Patient age and gender distribution in the material at implant placement.

Table 1 Length and Location of Implants

	Implant location				
Implant length	Right distal	Right mesial	Left mesial	Left distal	Total
7 mm	1	1	1	3	6
10 mm	13	10	10	10	43
13 mm	24	17	16	28	85
15 mm	50	46	51	49	196
18 mm	27	38	35	25	125
20 mm	4	7	6	4	21
Total	119	119	119	119	476

was cast in cobalt-chrome alloy. Artificial resin teeth were used in all but one case, in which a titanium framework and low-fusing porcelain veneer was used. All patients received complete-arch prostheses extending from the first molar region on one side to the first molar region on the other side, with a distal cantilever ranging from 10 to 22 mm. In the maxilla, 65 patients had a conventional complete removable denture and 33 patients had an implant-supported fixed prosthesis (Table 2).

The patients were followed up according to the routine protocol at the department. This included annual checkups and radiographic examinations immediately after prosthesis placement (year 0) and at subsequent 1-year, 5-year, and 10-year examinations. During the follow-up period 21 patients dropped out of the study. Of these, 11 patients died, 2 were not healthy enough to appear for checkups, 5 ceased coming for other reasons, 1 moved to another part of the country, 1 did not pay the treatment fee and was not examined after the 1-year checkup, and 1 patient was excluded when additional distal implants were placed after nerve transposition. However, all these patients were included in the study for as long as they attended the follow-up examinations and additional implants had not been placed.

Clinical follow-up examinations included assessment of occlusal and peri-implant conditions. The fixed prostheses were checked for clinical stability but were not detached to examine mechanically the osseointegration of the individual implants. Therefore, the implant results are given as survival rates (not as success rates) according to Albrektsson and Zarb.[6] From the patient records, both surgical and technical complications were noted.

For the radiographic examinations, either routine intraoral periapical radiographs or scanograms obtained with the Scanora x-ray unit (detailed narrow-beam radiographs) (Orion Corporation Soredex, Helsinki, Finland) were used, as described earlier.[7,8] The radiographs were studied for signs of disintegration and other pathology related to the implants. Marginal bone levels at the implants were measured mesially and distally. Radiographs taken after the fixed prosthesis was completed (year 0) and at the 5-year examination were compared. All measurements were in bone scores using the threads of the implants as a measuring scale.[7,8] These scores were used for individual comparisons. With a known distance between the implant threads, the mean bone changes in millimeters could then be calculated for the whole group of patients. Fifty-three patients were followed for 5 years or more, but 3 of them refused to have radiographs taken at the 5-year examination. In 1 case the radiographs were lost. Therefore, the radiographic material for comparison of marginal bone levels comprised 49 patients. Of these, 1 patient had an implant replaced after 1 year, and 1 patient had an implant removed after 5 years; hence 194 implants were evaluated after 5 years.

For statistical evaluations of differences between groups of patients, the Chi-square test and Student's *t* test were used.

Table 2 Fractures of Artificial Resin Teeth Grouped According to the Dental Status of the Opposing Arch

Maxilla	Fracture occasions 1	2	3	4	5	6	No. of patients with fractures	No. of fracture occasions
Natural dentition and/or FPD (n = 14)	1	1	0	1	0	0	3	7
Natural dentition and RPD (n = 4)	0	0	0	0	0	0	0	0
Complete removable denture (n = 65)	3	2	0	1	0	0	6	11
Implant-supported fixed prosthesis (n = 33)	3	5	4	1	1	1	15	40
Implant-supported overdenture (n = 3)	0	0	1	0	0	0	1	3
Total	7	8	5	3	1	1	25	61

Table 3 Years of Follow-up for the Total Patient Material and by Gender

No. of patients	Years of follow-up 1	2	3	4	5	6	7	8	9	10	11	Total
Male	4	2	11	9	10	4	2	2	1	2	1	48
Female	3	5	17	15	17	8	3	3	0	0	0	71
Total	7	7	28	24	27	12	5	5	1	2	1	119

RESULTS

Of the 119 patients, 105 were followed for 3 years or more and 53 for 5 years or more (Table 3). No implants failed before placement of the prostheses. Two of the 476 implants placed and loaded failed; 1 failed after the first year and 1 failed after 5 years. A third implant, which had osseointegrated, was removed because of pain and discomfort resulting from placement too close to the alveolar nerve. These 3 implants were all in the group of patients followed for 5 years or more. Consequently, the survival rate was 98.6% for the implants followed for 5 years or more. All patients continued to have a fixed implant-supported prosthesis.

Two of the patients who had lost 1 of the 4 implants continued to use their fixed prosthesis, now supported by only 3 implants, without further complications. They were therefore still included in the study. One patient had a new implant placed to replace the implant that was removed after 1 year. Surgical complications were found in 2 patients; 1 patient suffered from paresthesia of the right lower lip, and 1 implant was removed because of pain, as described above.

During the follow-up, 3 patients were found to have mobile prostheses that required tightening of the screw joints. Framework fractures were recorded for 5 patients, 3 in the group with gold-alloy frameworks (n = 103) and 2 in the group with titanium frameworks (n = 15), a nearly significant difference. All fractures occurred at or posterior to the distal abutment. Four of the patients with framework fractures had an implant-supported prosthesis in the maxilla and 1 patient had a conventional complete denture. Fractures of artificial resin teeth were found frequently; 25 of the 119 patients experienced fractures of resin teeth on 61 occasions (Table 2). The fractures were of different kinds, ranging from fractures of the resin teeth, to fractures of part of the acrylic base and resin teeth, to loosening of the resin teeth. There was a significant difference between the group with a conventional complete maxillary denture and the group with a maxillary implant-supported fixed prosthesis. Six of 65 patients (9%) with removable maxillary dentures experienced artificial tooth fracture in the mandibular fixed prosthesis, compared to 15 of 33 patients (45%) with a maxillary fixed implant-retained prosthesis ($P < .001$).

Table 4 Marginal Bone Level Changes After 5 Years, Measured in Implant Threads

Change in bone level (no. of threads)	Right distal		Right mesial		Left mesial		Left distal	
	d	m	d	m	d	m	d	m
1	1	—	—	—	—	—	—	—
0	36	42	34	32	34	28	41	36
–1	7	5	9	12	9	12	6	8
–2	2	1	3	2	4	4	—	2
–3	3	1	—	1	—	3	1	2
–4	—	—	2	1	1	—	—	—
–5	—	—	—	1	—	1	1	1
–6	—	—	1	—	1	—	—	—
–7	—	—	—	—	—	—	—	—
–8	—	—	—	—	—	1	—	—

d = distal of implant; m = mesial of implant.

The great majority (71%) of sites examined after 5 years showed no marginal bone loss over the 5-year period or loss of only 1 thread (Table 4). Only 6 implants (11 sites) showed bone loss that exceeded 3 threads. Of these, 1 implant demonstrated bone loss of 3 threads after 1 year, but no further bone loss was seen exceeding 4 threads at the 5- and 10-year follow-up examinations. The mean bone loss was calculated to be 0.5 mm after 5 years. It was also found that the mesially placed implants had, on average, bone loss of 0.6 mm, compared to 0.3 mm at the distally placed implants. This difference was found to be statistically significant ($P < .01$). There was no significant difference in marginal bone loss between groups having different dental conditions in the maxilla. No differences related to age or gender were noted.

DISCUSSION

This study showed an implant survival rate of 98.6% after 5 years for the 194 implants with available radiographs, which is comparable to the best results from other researchers who used more implants to support a fixed prosthesis.[2,4,5,9–11] For the mandible, this result strongly supports the findings by Brånemark et al, leading to the hypothesis that the number of implants needed to support a fixed prosthesis could be reduced to 4 (each at least 10 mm long).[2]

The mean marginal bone loss after 5 years was 0.5 mm. This result meets the success criteria set by Albrektsson et al.[12] The majority of implants showed no marginal bone loss or loss of only 1 thread after 5 years. Six implants showed a loss of more than 3 threads. Some of these implants might be lost in the future, but a steady state might also have been established at the level found after 5 years.[13] None of the implants showed any signs of disintegration radiographically or upon clinical examination.

In this study, a larger amount of bone loss was seen on the mesially placed implants. Similar results have been seen in other studies.[5,11,14] There are at least 2 possible explanations for this finding: either greater biomechanical forces in this area, or a thinner alveolar bone crest in this region. Lindquist et al[11] found a significant correlation between bone loss and smoking/poor oral hygiene, especially for anteriorly placed implants. However, smoking and hygiene variables were not addressed in the present study.

As in previous studies,[7,8] bone levels were measured with scores, using the threads of the implants as a measuring scale. The reason for not measuring primarily in millimeters or tenths of a millimeter is the lack of accuracy in measurements of marginal bone levels from radiographs. It has been shown that a change in projection of the vertical angulation by just 1 degree will result in a change of 0.1 mm in the measured bone level.[15] It has also been suggested that any measured change in bone height of less than 1 mm is likely to be an artifact.[16] Further, it has also been reported that bone loss must exceed 0.47 mm to be detectable.[5] However, in large patient material, errors in measured bone height related to projection and other technical changes probably will be self-compensating. Therefore, the mean marginal bone loss in the total patient material was calculated in tenths of a millimeter to permit comparison with other studies.

The dropout of 21 patients is quite reasonable considering the age distribution of the patient material. There was no indication of any implant failure among those not attending the annual checkups. It should also be emphasized that no negative symptoms were found in the 2 patients who continuously used their fixed prosthesis supported by only 3 implants after loss of the fourth implant. The patient who was excluded from the study after the placement of additional distal implants had experienced repeated abutment screw fractures caused by too short a distance between the mental foramina, which resulted in unfavorable loading. The case was described earlier.[17]

Technical complications in the present material were somewhat higher than those seen in most other studies.[10,11,17–21] There were 5 framework fractures; 2 of these were laser-welded titanium frameworks as originally designed, which have been reported to be somewhat problematic.[20,21] The 3 fractured gold-alloy frameworks were technically not well designed. No indication was found that the number of supporting implants influenced the frequency of framework fractures.

The number of resin tooth fractures among the mandibular prostheses was very high. Dental conditions in the maxilla played a role. Patients with a maxillary implant-supported fixed prosthesis exhibited a significantly greater number of mandibular resin tooth fractures, compared to patients wearing a maxillary conventional complete denture ($P < .001$). A similar tendency was observed by Carlson and Carlsson,[19] but their patient material was too small for further analysis. In the present material, 33 patients had fixed implant-supported prostheses in both the maxilla and the mandible. The results indicate that in such cases the use of artificial resin teeth probably should be avoided. A simple explanation of the outcome with occluding resin teeth in the different groups is that patients with fixed implant-supported restorations in both arches used higher occlusal forces than the patients with a complete maxillary denture.

The present results—a high implant survival rate and favorable marginal bone levels after 5 years—indicate than no more than 4 implants may be needed in most edentulous mandibles to support a fixed prosthesis. From an economic point of view, this is important information since the restoration can be made less expensive for the patient. The treatment resources can thus be used in a more cost-effective way.

CONCLUSIONS

From the present study the following may be concluded.

1. Four implants were deemed adequate for the support of complete-arch fixed cantilevered prostheses.
2. The use of artificial resin teeth occluding in patients with fixed implant-supported prostheses in both arches can be questioned.

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