Fixed Partial Prostheses Supported by 2 or 3 Implants: A Retrospective Study up to 18 Years

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Purpose: *The purpose of this study was to evaluate and compare the long-term performance of fixed partial prostheses supported by 2 or 3 implants.* ***Materials and Methods:*** *All patients treated with fixed partial prostheses supported by either 2 or 3 implants during the period 1985 to 1998 were included in this retrospective report. Annual clinical follow-up examinations were performed, with special attention to stability of the prostheses and peri-implant and occlusal conditions. Radiographic examination was performed when the prostheses were delivered (year 0) and subsequently at 1-year, 5-year, and 10-year examinations.* ***Results:*** *A total of 178 patients had received fixed partial prostheses (FPPs) during this period of whom 123 (77 women and 46 men) were available for follow-up (mean age = 65 years, range 32–91). These 123 patients received a total of 146 implant-supported FPPs (63 two-implant– and 83 three-implant–supported) supported by 375 implants. The mean observation periods for the 2- and 3–implant-supported restorations were 9.6 years and 9.4 years (range, 5 to 18 years), respectively. Survival rates for the 2- and 3-implant–supported prostheses were 96.8% and 97.6%, respectively. The implant survival rate after loading was 98.4% for both groups. The mean bone loss at the 5-year follow-up was 0.3 mm for the 2 groups. No significant differences in bone loss (*$P > .05$*), implant failure rate (*$P > .05$*), or incidence of mechanical complications (*$P > .05$*) were found between the 2 prosthesis designs. The complications differed, significantly, with more loose gold and abutment screws in the 2-implant–supported group (*$P < .05$*) and more porcelain fractures in the 3-implant–supported group (*$P < .05$*).* ***Conclusion:*** *The 2-implant–supported partial prostheses exhibited long-term clinical performance comparable to prostheses supported by 3 implants.* (Comparative Cohort Study) Int J Oral Maxillofac Implants 2006;21:567–574

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Osseointegrated dental implants have successfully been used for more than 30 years for the replacement of missing teeth. In the original Brånemark protocol, the method was used to provide fixed prostheses for edentulous patients.[1–3] Today, the osseointegration technique is common in the treatment of both partially and totally edentulous patients; the majority of patients receiving implants are partially edentulous.[4–7]

In the oral environment various loading patterns can be expected, resulting in complex loading forces.[8] The totally edentulous situation generally offers a more biomechanically ideal situation, as it is possible to use several implants in a curvilinear configuration. Conversely, in the partially edentulous patient the conditions differ, and fewer implants are required. These implants are often placed in a straight-line pattern that results in less resistance to nonaxial force application.[9,10]

In a short-span restoration, such as the 2-implant–supported prosthesis, the implants will of course be arranged in a straight line. In this situation,

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Table 1 No. of FPPs According to No. of Implants per Restoration, Gender, and Age of the Patients at Follow-up

	Men		Women		
Age (y)	2 implants	3 implants	2 implants	3 implants	Total
30 to 39	4	2	3	2	11
40 to 49	3	2	3	0	8
50 to 59	2	6	7	4	19
60 to 69	3	12	16	16	47
70 to 79	4	9	11	20	44
80 to 89	3	4	3	6	16
90 to 99	0	0	1	0	1
Total	19	35	44	48	146

bending moment may be created from lateral force on the occlusal surface. If the 2-implant prosthesis is extended with an anterior or a posterior cantilever, the forces will increase because of the leverage of the extension, with a conceivable risk for adverse loading conditions. Placement of an additional implant creates a curvilinear arrangement of implants while distributing occlusal load more favorably.

The design of the prosthesis is another factor that affects the load of the implant. An overcontoured occlusal anatomy in the buccolingual aspect of the prosthesis may introduce an increased load due to the bending moment from the axial and nonaxial force components acting on the prosthesis.[11]

A number of investigators have reported good results with implant-supported fixed partial prostheses (FPPs) in the partially edentulous situation with a follow-up of at least 5 years.[12–16] However, more mechanical problems have been reported in partially edentulous patients than in totally edentulous ones.[9,12] Other studies have reported a higher rate of failures for prostheses supported by 2 implants than for those supported by 3 implants.[17,18] From these results it could be assumed that a reduction of the number of supporting implants in partially edentulous patients may jeopardize the long-term treatment outcome and increase the frequency of biological and mechanical complications. Clinical research in implant dentistry has focused on implant survival. In many reports, results are given on a variety of prostheses, but detailed information on the designs is not provided.[19] The purpose of this study was to evaluate the long-term performance of FPPs supported by 2 or 3 implants after a period of 5 or more years in function.

MATERIALS AND METHODS

Between 1985 and 1998 a total of 178 patients were consecutively treated with implant-supported FPPs, supported by 2 or 3 implants, at the Department of Prosthetic Dentistry, Postgraduate Dental Education Center, Örebro, Sweden. One hundred twenty-three of these patients with 146 dental restorations participated in the study (77 women and 46 men; mean age, 65 years; range, 32 to 91 years). The age and gender distribution in the 2 treatment groups are shown in Table 1. The study included a self-administered questionnaire, data collection from dental records, and a clinical examination. Fifty-five patients were lost to follow-up: 26 died, 16 had moved to another county, and 13 declined to continue with the study because of deteriorating health or mobility.

All patients were treated by a 2-stage procedure with Brånemark System implants (Nobel Biocare, Göteborg, Sweden) with a turned finish. The implants placed were 6 to 18 mm long (mean, 13 mm). Prosthetic treatment was performed with freestanding screw-retained FPPs supported either by 2 or 3 implants. The protocol called for a follow-up period of at least 5 years.

For the majority of the restorations, the dentition in the opposite jaw was natural teeth or fixed partial dentures (n = 131). Only 7 restorations occluded against removable dentures, and 8 prostheses occluded against implant-supported FPPs. Detailed information on treatment outcome, additional prosthetic treatment, and complications during the follow-up period could be obtained from the patient's records, since a majority of the patients participated in annual recall examinations.

In accordance with department protocol, yearly clinical follow-up examinations were performed with special attention to stability of the prostheses and peri-implant and occlusal conditions. Radiographic examination was performed when the prostheses were delivered (year 0) and subsequently at 1-year, 5-year, and 10-year examinations. At the clinical examination, the peri-implant conditions were assessed, and the type of opposing occlusion was registered.

Data concerning number of implants placed, early failures, and diameter and length of loaded implants were collected from the patients' records. From the day of prosthetic placement, and during the follow-up period, complications of a biological and/or mechanical nature were registered. These included loss of osseointegration, fistulae, peri-implantitis, damage of the veneering material, loose retaining or abutment screws, fracture of retaining or abutment screws, and fracture of framework/implant. The prostheses were not removed in order to estimate the stability of separate components or implants as the observation period of 5 years or more seemed sufficient enough for such complications to appear clinically and/or in the radiographs. Therefore, implant survival was defined according to Albrektsson and associates.[20] A specialist in oral radiology analyzed the radiographs. The abutment-implant connection was used as a reference point, as the implants were normally placed with the abutment-implant connection near the alveolar crest according to the surgical protocol. Bone loss was evaluated by comparing the radiographs obtained at baseline and with those obtained at the 5- and 10-year follow-up visits. The threads were used as a measuring scale, and registration of marginal bone loss was made in relation to the nearest individual thread on the mesial and distal surfaces of each implant. With a known distance between the threads (0.6 mm), bone loss in millimeters could be estimated.[9,21]

Patient satisfaction concerning function, esthetics, and experience of implant treatment was assessed through a questionnaire at the time of the clinical examination.

Statistical Analysis

All data were analyzed in Statistical Package for Social Sciences (SPSS) version 12 (SPSS, Chicago, IL). An independent Student *t* test was used in order to detect differences between type of construction (2- and 3-implant–supported prostheses) and clinical variables. A paired Student *t* test was applied to evaluate intra-group radiographic bone loss at the 5- and 10-year follow-up examinations. The level for statistical significance was set at $P < .05$.

Table 2 No. of Restorations According to Follow-up Time in Years

Follow-up	2 implants	3 implants	Total
5 to 6	6	3	9
6 to 7	8	12	20
7 to 8	2	13	15
8 to 9	13	15	28
9 to 10	7	8	15
10 to 11	7	8	15
11 to 12	7	10	17
12 to 13	4	5	9
13 to 14	6	3	9
14 to 15	0	4	4
15 to 16	2	0	2
16 to 17	1	1	2
17 to 18	0	0	0
18 to 19	0	1	1
Total	63	83	146

RESULTS

Demographics

The study sample comprised 123 patients with 146 prostheses, supported by 375 implants. Sixty-three (43.2%) of the prostheses were supported by 2 implants, and 83 (56.8%) of the prostheses by 3 implants having a mean service time of 9.6 years (range, 5 to 16 years) and 9.4 years (range, 5 to 18 years), respectively (Table 2).

One hundred twenty-eight (88%) of the prostheses were made with a cast framework of precious alloy veneered with porcelain. Fifteen (10%) restorations were fabricated with a cast gold framework with acrylic resin teeth. In 3 cases (2%) the framework was fabricated in titanium and veneered with porcelain. Thirty-five (55%) of the 2-implant–supported prostheses and 26 (31%) of the 3-implant–supported prostheses were constructed with uni- or bilateral cantilevers (Table 3).

The position of the prostheses in relation to the remaining dentition was classified as anterior (prostheses in canine and incisor area) or posterior (prostheses with a posterior position in relation to remaining dentition). The most frequent position for both designs was posterior: 87% of FPPs supported by 2 implants and 94% of FPPs supported by 3 implants (Table 4). Details regarding the implants placed are shown in Table 5. Short implants (6 to 8.5 mm) were found with a minor frequency for both designs (4.4%), and implants (n = 11) with a wider diameter (5 mm) were used in a few cases in the posterior maxilla, mostly in 3-implant–supported FPPs.

Table 3 Design of 2-Implant– and 3-Implant–Supported Prostheses

	2-implant		3-implant		Both types	
	n	%	n	%	n	%
No cantilever	28	44	57	68	85	58
Unilateral cantilever	30	48	23	28	53	37
Bilateral cantilever	5	8	3	4	8	5

Table 4 No. of FPPs According to Position in the Jaws and the No. of Supporting Implants

	Maxilla		Mandible		
Position	2-implant	3-implant	2-implant	3-implant	Total
Posterior to canine	21	14	17	27	79
Posterior including canine	9	29	8	8	54
Anterior	7	4	1	1	13
Total	37	47	26	36	146

Twelve restorations in the posterior-to-canine position were 2-unit restorations.

Table 5 No. of Implants of Various Lengths in 2-Implant– and 3–Implant-Supported Prostheses

Implant length	2-implant	3-implant	Both types
6 mm*		1	1
7 mm	1	6	7
8 mm*	2	2	4
8.5 mm		1	1
10 mm	29	89†	118†
12 mm*		3	3
13 mm	35	49	84
15 mm	42	76	118
18 mm	17	22	39
Total	126	249	375

The implants used were 3.75 mm in diameter, except in a few cases where 4-mm-wide implants were used. Five-mm-wide implants were used in 11 cases.
*Five-mm-wide implants were used.
†Five-mm-wide implants were used in 3 cases.

Implant Loss

There were 4 implant failures before prosthetic placement; 6 implants failed after loading. For 2-implant restorations, 2 implants were lost in 2 patients after loading. One of the implants was lost in an anterior restoration in the maxilla and could probably be explained by trauma. The second loss, also in the maxilla (free-end with cantilever), appeared during the second year, probably due to unfavorable loading conditions, as the patient had Angle Class II malocclusion and showed excessive signs of bruxism. Both patients received new implants with subsequent prosthetic treatment and have been subsequently followed for more than 5 years; hence, both are included in the 5-year follow-up.

With 3-implant prostheses, loss of integration was seen in 3 patients and in 4 implants. In 1 FPP, the central implant had to be removed after 8 years in function because of excessive marginal bone loss. The neighboring implants, however, showed no or minor signs of marginal bone loss. In a second case, 1 implant was removed because of an infection in the apical part of the implant during the fifth year in function. After removal of these 2 implants, the prostheses were converted to 2-implant–supported restorations. In 1 case, the remaining implants were subsequently cantilevered bilaterally. Both restorations are still in function and have passed the 10-year follow-up without further complications. In the third case, 2 implants in an anterior restoration were lost because of trauma.

Bone Loss

Radiographs were obtained shortly after delivery of the prostheses (baseline) and at the 1-, 5-, and 10-year follow-up visits. The bone level at baseline was above the first thread for most implants (82%), but 35 (9.5%) of the implants presented a bone level at the third or fourth thread. However only 4 of these implants with an initial bone loss > 2 threads at baseline exhibited further bone loss at the 5-year follow-up exceeding 0.6 mm, thus indicating that a steady state was established for them after the baseline registration. Initial bone loss was more pronounced for wide (5 mm) implants: 6 of 11 wide implants had a bone level at or below the second thread at baseline. The difference between wide implants and implants ≤ 4 mm wide was statistically significant ($P < .05$).

Table 6 Frequency Distribution of Marginal Bone Loss—Mean Percentage of All Included Implants at the 5-Year and 10-Year Radiographic Examinations

	2-implant		3-implant	
Mean loss (mm)	5 y (n = 126)	10 y (n = 64)	5 y (n = 249)	10 y (n = 111)
0	67.5	48.4	69.5	67.6
0 to 1.2	29.3	46.9	27.7	28.8
> 1.2	3.2	4.7	2.8	3.6

Table 7 Soft Tissue Conditions of 2-Implant– and 3-Implant–Supported Prostheses: Attached Peri-implant Mucosa Versus Nonattached Peri-implant Mucosa

	2-implant (n = 63)		3-implant (n = 83)	
Peri-implant soft tissue	Attached	Nonattached	Attached	Nonattached
Healthy	86	11	83	10
Inflamed	0	1.5	3.5	0
Suppuration present	1.5	0	3.5	0

Percentage of prostheses shown for each condition.

Bone loss during the first 5 years of follow-up was small in most cases, with a mean bone loss of 0.3 mm (range, +1.2 to −3.0 mm). Sixty-nine percent of the implants had no bone loss, and 21% had bone loss not exceeding 0.6 mm from baseline to the 5-year follow-up (Table 6).

Maximum radiographic bone loss of all individual implants for which radiographs were obtained at both the 5- and 10-year follow-ups (175 implants supporting 69 restorations) was calculated. The 2-implant–supported restorations (n = 32) had a maximum mean bone loss of 0.4 mm (range, +0.6 to −1.8 mm; SD, 0.51) at the 5-year follow-up and 0.5 mm (range, +0.6 to −1.8 mm; SD, 0.56) at the 10-year follow-up; the difference between the 2 time points was not statistically significant. The corresponding figures for the 3-implant–supported restorations (n = 37) were a mean of 0.2 mm (range, +0.6 to −1.8 mm; SD, 0.43) and 0.3 mm (range, +0.6 to −2.4 mm; SD, 0.55); the difference between the 2 time points was not statistically significant.

Only 6 implants showed a bone loss exceeding 0.6 mm from the 5-year to the 10-year follow-up examination. In 1 FPP supported by three 7-mm-long implants in the molar region in the mandible, a pronounced loss of bone support was observed around all 3 implants at the 10-year radiographic examination. Thus, these implants are calculated as failures. Together with the implant losses this gives a total failure of 13 implants. An implant survival rate of 96.5% was calculated. Four FPPs were lost; thus, the success rate for the FPPs was 97.3%.

Gingival Health

Gingival conditions were generally healthy (Table 7). No statistically significant differences were found between the 2- and 3-implant–supported constructions with respect to soft tissue conditions.

Mechanical Complications

For both designs, more than two thirds of the FPPs showed no complications. All complications registered during the follow-up period are shown in Table 8. The most common complications were fractures of the porcelain and loose abutment or retaining screws. There were more veneer complications in the 3-implant–supported prostheses, and 2-implant–supported prostheses more frequently presented loosening of abutment and retaining screws. Both of these differences were statistically significant ($P < .05$). No relationships were found between the complication rate and gender, implant/prosthesis location (maxilla or mandible), position of the prosthesis, or number of supporting implants. Whether the canine region was included in the restoration did not affect the complication rate.

On the patient level, 94 patients had no complications needing adjustment, 12 patients needed adjustment on 1 occasion, 7 patients on 2 occasions, 3 patients on 3 occasions, 3 patients on 4 occasions, 2 patients on 5 occasions, and 2 patients on 6 occasions.

Patient Satisfaction

The treatment outcome for chewing ability was measured through a questionnaire. Improvement in

Table 8 Percentages of 2-Implant– and 3-Implant–Supported Prostheses for Which Mechanical Complications Were Observed

Type of complication	2-implant (n = 63)	3-implant (n = 83)
No complications	77	71
Veneer fracture (clinical polish)	6	17
Veneer fracture (attended by technician)	0	4
Loose retaining screw	3	4
Loose abutment screw	11	3
Abutment screw fracture	3	0
Fracture of framework	0	1

chewing ability was reported by 67% of the patients, 30% experienced no change, and 3% of the patients reported that their ability to chew had decreased. The corresponding figures for the esthetic appearance were: improved in 61% of the patients, unchanged in 35%, and worse in 4%. The treatment outcome in relation to expectations was reported as "completely satisfied" by 88% of the patients. Ninety-seven percent of the patients said that they would recommend the treatment to others.

DISCUSSION

The protocol of the Department of Prosthetic Dentistry for implant treatment in partially edentulous patients has been to place 3 implants when possible instead of 2 because of biomechanical considerations. Only in cases where available bone volume was not sufficient for 3 implants, or replacement of only 2 teeth was necessary, was the use of 2 implants the method of choice. However, in cases where prostheses were supported by only 2 implants, the implants tended to be somewhat longer (Table 5); thus, bone quality for the 2 groups was thought to be similar.

Of the originally treated 178 patients only 123 patients were available for follow-up, corresponding to a participation rate of 69%, which is comparable to other long-term follow-up studies.[4,22] The dropout rate could be explained by the long observation period, up to 18 years, and the high mean age of the patients. Seventy-five percent of the patients not attending the follow-up had either expired or moved from the county, which suggests that the present results were probably not biased by the dropouts.

Failure of a single implant in the treatment of a totally edentulous patient does not necessarily jeopardize the entire restoration, since the remaining implants may provide sufficient support for the prosthesis. However, in the partially edentulous situation, particularly prostheses with 2-implant support, the situation is more critical when 1 implant is lost. In addition to placement of a new implant, a remake of the prosthesis will most likely be necessary. In this study, 2-implant–supported prostheses had to be replaced because of the loss of a single supporting implant, while in 2 cases of 3-implant–supported prostheses, the prostheses could still be maintained.

In the present study, the overall survival rate for both types of FPPs was 97.3% after a mean observation period of 9 years, with no difference between the two groups. The results are in agreement with other similar follow-up studies where the survival rate of partial prostheses ranged from 80% to 100% with a shorter follow-up than in the present study.[17,23–27]

The implant survival rate was 96.5%, with no significant difference between the 2 types of prosthetic design. This result compares favorably to meta-analyses of implants in partially edentulous patients, which reported survival rates of 93.7% to 95.4% after 5 to 7 years and 92.8% after 10 years.[19,28–30] Other recently published studies of patients treated by specialists reported survival rates of 95.4% to 97.6%.[12,15,25,31] The relatively good results of the present study (eg, high prosthetic success rate and low incidence of implant losses) may be attributed to the use of long implants (mean of 13 mm), since other studies have reported higher failures for short implants.[16,32,33]

In the present study, prostheses were most often placed in the posterior regions; posterior restorations were roughly evenly distributed between the maxilla and the mandible. Prostheses with 2-implant support were more often extended with cantilevers than 3-implant–supported restorations, which may have increased the complication rate. Diverging results have been published regarding the effects of cantilevers on potential complications.[30,34]

For more than 70% of the prostheses in the present study, no mechanical complications were observed. However, 2-implant–supported prostheses presented more often with loose retaining and abutment screws and abutment screw fracture (17%) than prostheses supported by 3 implants (7%). This pattern is in accordance with other authors' reports of mechanical problems.[7,17,18,35]

A retrospective study by Wennerberg and Jemt of implant treatment in the partially edentulous patient concluded that there appeared to be a greater risk of mechanical implant overload when implants were placed in the maxilla to support a unilateral free-end restoration.[36] This was found to be particularly true for restorations with 2-implant support in the canine area. Loosened screws were found more frequently when only 2 implants supported the prosthesis, as in the present study.

In the present study more severe mechanical complications, such as implant fractures, were not observed. Most problems with loose screw joints were managed by a thorough occlusal adjustment; recurrence was rare. It was observed that mechanical problems, such as loosened retaining and abutment screws, tended to decline with time. It can be speculated that the greater frequency of mechanical problems observed in prostheses with 2-implant support was related to the inferior resistance to lateral forces of these prostheses compared to the 3-implant prostheses.

The mean marginal bone loss at the 5-year radiographic examination was similar for both types of prosthetic design. The mean bone loss observed in the present study was somewhat lower than that reported by other similarly designed studies.[17,37] In the present study, implants in 2-implant– and 3-implant–supported FPPs exhibited a mean bone loss from the 5-year to the 10-year follow-up of 0.1 mm, thus indicating that a steady state was achieved in most cases after the first year.

However three 7-mm-long implants supporting 1 FPP in the mandibular molar region showed progressive bone loss leading to total failure. These implants had an initial bone loss of 1 to 2 threads. Slow but progressive bone loss was seen in successive follow-up radiographs, indicating that the use of only short implants as support for a FPP could be a risk factor in areas where heavy loading is experienced. The magnitude of bone loss from implant placement to baseline in this study was similar to that reported by Åstrand and associates.[38] In the present study, 9.5% of the implants displayed a bone loss at baseline of > 2.6 mm, which could be a problem in prostheses supported only by short implants. However, the number of implants with bone loss exceeding 0.6 mm after the first year was fairly low in this study, which is similar to other studies.[7,26,39]

The soft tissue conditions around both types of constructions were generally good, and soft tissue pathology was seen in only about 6% of all cases. If present, it was mostly seen at solitary implants, and seldom with signs of more severe reactions or involvement of bone tissue.

In conclusion, this study shows that the long-term performance of implant-supported partial prostheses is generally good (ie, implant survival rate of 96% to 98%). No significant differences were found between the 2 designs studied with regard to implant loss, prosthesis survival, or mechanical complications.

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