Implant Treatment with Fixed Prostheses in the Edentulous Maxilla. Part 2: Prosthetic Technique and Clinical Maintenance in Two Patient Cohorts Restored Between 1986 and 1987 and 15 Years Later

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Purpose: Implant treatment using osseointegrated implants has been performed for more than 40 years, but limited knowledge is available on how treatment outcomes have changed over time. The aim of this study was to report and compare the prosthetic treatment outcomes from two patient cohorts provided with fixed implant prostheses in the edentulous maxilla between 1986 and 1987 (early) and 2001 to 2004 (late) at the same clinic. ***Materials and Methods:*** The two groups of patients comprised 76 and 109 edentulous patients consecutively provided with 450 and 670 Brånemark System implants and fixed screw-retained prostheses, respectively. Both groups were followed for 5 years with regard to prosthetic treatment, clinical maintenance, and complications. ***Results:*** Altogether, 37 patients (20%) were lost to follow-up during the 5 years, and more patients were noncompliant in the late group ($P < .05$). Prosthetic treatment was performed using significantly less chair time in the late group ($P < .05$), and 22 and 68 patients were followed for 5 years without any reported complications in the early and late groups, respectively ($P < .05$). The 5-year prosthesis cumulative survival rate was 97.1% in the early group and 100.0% in the late group. Patients in the late group presented fewer problems with diction and veneer fractures, and fewer patients had their prostheses temporarily removed for adjustments ($P < .05$). ***Conclusion:*** Prosthetic treatment and maintenance of implant-supported fixed prostheses improved significantly between the groups. *Int J Prosthodont 2011;24:356–362.*

The first edentulous patients were treated with fixed prostheses supported by osseointegrated implants in 1965. Since this procedure was controversial at that time, it was considered important to clinically document and follow-up with these early patients to prove its clinical efficiency. Accordingly, data on the first patients were collected and published after 10 to 20 years of function.[1–3] Further early prospective studies were initiated during the late 1970s by the original team, reporting the treatment outcome of edentulous patients after 5 and up to 20 years.[4–6] These studies have been followed by long-term studies from other early-adopting centers, indicating similar encouraging results in the edentulous arch.[7–9] Patient groups were followed continuously at the Brånemark Clinic, Public Dental Health Care, Gothenburg, Sweden, when started in 1986, where the early protocol of clinical documentation of implant patients was also maintained. Accordingly, new groups of edentulous implant patients were formed at the clinic and followed continuously for 10 to 15 years.[10–13]

Based on all of these clinical follow-up studies, it can be suggested that, today, implant treatment of the edentulous arch is a well-documented prosthetic technique. Using the principles of osseointegration, the treatment protocol of edentulous patients has changed continuously and improved over the years. However, there are no studies available that have focused on the clinical changes of the protocol over a long time span, and no data are available on the comparability of present clinical procedures with historic data from early follow-up studies.[1–13]

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Table 1 Clinical Situation in the Mandible at the Time of First Surgery in the Maxilla

	Dentate			Edentulous	
Group	Teeth or tooth-supported partial denture	Removable partial denture	Mixed (teeth and implants)	Removable complete denture	Fixed implant-supported prosthesis
Early*	44	9	0	1	18
Late*	71	0	4	3	27

*Information not available for 4 patients.

The purpose of this study was to report changes in prosthetic treatment and the clinical performance between two groups of patients provided with fixed prostheses supported by implants in the edentulous maxilla between 1986 and 1987 and approximately 15 years later at the same specialist clinic (Brånemark Clinic). The hypothesis was that changes in the clinical protocol over a 15-year period would improve the clinical results and reduce the prevalence of complications during a 5-year follow-up period.

Materials and Methods

The present study is the second publication covering two groups of patients consecutively rehabilitated in the edentulous maxillae with implant-supported fixed prostheses at the Brånemark Clinic from January 1986 to December 1987 (early group) and from January 2001 to November 2004 (late group).[14] Both groups have been described more thoroughly in earlier publications,[11–14] where the first publication on this patient cohort covered the results from the implant surgery and the biologic response in more detail.[14] Similar strict clinical protocols and follow-up procedures were used in both groups, allowing for comparisons between the two groups using a "RetroPro" approach (retrospective evaluation of prospectively collected data).[15]

Patient Groups

All patients consecutively provided with fixed prostheses supported by implants in the edentulous maxilla at the specialist clinic (Brånemark Clinic) during the two periods were included. However, implant patients first provided with removable dentures or treated with major bone grafts were excluded from the present study.[11–13] Furthermore, patients who received implants but not fixed prostheses at the clinic (two patients) or patients who had died before prosthesis placement (two patients) were also excluded.

The early group comprised 76 consecutively treated patients, 48 of whom were men (63.2%).[12,13] The mean age at implant surgery was 60.1 ± 11.60 years, and ages ranged from 32 to 75 years.[12,13] The late group comprised 109 consecutive patients, 54 of whom were men (49.5%). The mean age at implant surgery was 65.1 ± 11.28 years, and ages ranged from 38 to 92 years.[14]

Thirty-five (46%) and 56 (51%) patients reported no general health problems or use of medication in the early and late groups, respectively. Information on smoking habits was available on 34 (44.7%) and 99 (90.8%) patients, presenting 21 (61.8%) and 50 patients (51.0%) with smoking habits, respectively.

Distributions of the clinical situations in the opposing arch are presented in Table 1.

Prosthetic Treatment

As accounted for in more detail in the earlier study,[14] implant placement was based on a two-stage standard surgical procedure in both groups,[16] with an average healing period of 5 to 8 months between implant surgery and abutment connection. Altogether, 450 and 670 straight Brånemark System implants were placed in the early and late groups, respectively.

In the early group, patients had their complete dentures temporarily relined with a soft tissue conditioner (Viscogel, Dentsply) approximately 2 weeks after the first surgery, followed by a hard tissue denture relining after another 2 to 4 weeks. In the late group, dentures were relined with a soft tissue conditioner after 1 to 2 weeks (Coe-Soft, GC), and no permanent relining was performed during the healing period. After stage-two surgery, a surgical dressing (Coe-Pak Periodontal Dressing, GC) was applied

Fig 1 Edentulous patients in the early group were provided with fixed implant-supported maxillary prostheses that were focused on oral health and access for maintenance with clinically longer abutment cylinders.

Fig 2 Edentulous patients in the late group were provided with fixed implant-supported maxillary prostheses that were focused more on esthetics with clinically short abutment cylinders.

and retained with healing caps in the early group of patients.[4,16] This procedure prevented the patients in the early group from using their maxillary complete dentures during the healing period and final prosthetic treatment. However, patients in the late group were provided with their dentures approximately 1 week following stage-two surgery, which were temporarily relined with the soft tissue conditioner during the following healing period and final prosthetic treatment.

Final prosthetic treatment in the early group was completed according to a five-appointment standard protocol.[10] This began with taking final impressions (appointment 1) using either impression plaster (Dr Kühns's Abdruckgips, Ernst Hirnischs) or a polyether impression material (Impregum Penta, 3M ESPE) in a custom-made or standard plastic impression tray with an open top.[17,18] This was followed by arch recordings using a try-in base (appointment 2), esthetic and occlusal assessments of the setup of the artificial denture teeth (appointment 3), try-in of the cast type III gold alloy frameworks (appointment 4), and eventual placement of the definitive prostheses with the framework supporting artificial resin teeth (appointment 5).[4,10,17] The prostheses included, on average, 10 teeth with posterior cantilevers of 7 to 12 mm in length. After insertion and final tightening of the locking screws 2 to 6 weeks later, the patients were scheduled for annual checkups only.[10]

An important change in the general design of the prostheses was performed between the early and late groups. In the early group, prosthesis design was focused on biologic health by choosing long clinical abutment cylinders and placing the prostheses away from the mucosa to allow optimal maintenance and mucosal health (Fig 1). For the late group, however, prostheses were designed more for esthetics by using shorter abutment cylinders and placing the prostheses closer to the mucosa (Fig 2). Otherwise, the basic prosthetic protocol was followed with only minor adjustments. Thus, custom-made impression trays were not used, and cast frameworks were replaced with computer numeric controlled Procera titanium frameworks (Nobel Biocare) in all patients.[18,19] The clinical standard protocol was further adjusted in the late group to allow for only four appointments, since try-in to ensure the fit of frameworks was not always considered necessary with the Procera technique.

Total chair time for the prosthetic treatment was scheduled to be 4.25 and 2.25 to 3 hours for the early and late groups, respectively. Additional appointments during follow-up were estimated to be of 45- and 30-minute durations, respectively.

Follow-up and Maintenance

After final tightening of the prosthetic screws, all patients in both groups were scheduled for similar follow-up protocols. Accordingly, patients were scheduled for checkups after 1 and 5 years in function but also recalled for additional checkups on an individual basis if necessary.[12–14] However, all patients were encouraged to contact the clinic whenever they had problems with their prostheses.[13,14] Intraoral apical radiographs were taken on a routine basis at the Radiological Specialist Clinic, Public Dental Health Service, Göteborg, Sweden, at the time of prosthesis insertion and after 1 and 5 years in function.[12–14]

Data were collected from patients' files, including all problems encountered during the follow-up period.[13,15] Prosthesis survival was defined as clinical maintenance of the original prosthesis to the termination of the study.

Statistical Analysis

Descriptive statistics and conventional life table analyses showing prosthesis cumulative survival rates (CSRs) were used in the present study. Differences between groups of patients were tested with regard to distributions using chi-square tests and with regard to mean values using the Student *t* test.

Overall statistical significance was set at 5%, and statistical comparisons were only performed on the patient level. Statistical tests were used with caution to limit problems with mass significance, avoiding testing for statistical differences in the material when no clear difference was indicated. Still, several individual statistical tests were performed in the present study (14 tests). To avoid false positive statistical results because of mass significance and to maintain an overall 5% level of significance, a correction of the *P* value was performed according to Bonferroni to a nominal level of $P < .004$ for the individual test.[20]

Results

Patients Lost to Follow-up

Altogether, 12 (15.8%) and 25 (22.9%) patients were lost to follow-up and withdrawn during the 5-year follow-up period in the early and late groups, respectively (Table 2). With the exclusion of 8 and 6 deceased patients, the dropout rates were 5.3% and 17.4% for 5 years. Reasons for withdrawal of the remaining patients (early, late) were: noncompliance (n = 1, n = 14), health (n = 1, n = 3), moved from the area (n = 2, n = 1), and controls at other clinics (n = 0, n = 1), respectively. More patients were noncompliant in the late group ($P < .05$). Another 2 patients were examined clinically in the late group, but they did not undergo radiographic examination. Accordingly, 84 patients were followed clinically, but only 82 patients underwent radiographic examination after 5 years in the late group.

Prosthesis Fabrication

The mean time from stage-two surgery to completion of the permanent prosthesis was 29.4 ± 6.86 and 40.7 ± 17.45 days for the early and late groups, respectively ($P < .05$).

Fifty-five patients in the early group (72.4%) were treated according to the five-appointment protocol. Extra appointments were related to esthetic assessment of tooth arrangements and occlusion (n = 15), try-in of cast frameworks (n = 3), and recording of arch relationship (n = 3). The corresponding number of patients following the set clinical protocol (four or five appointments) in the late group was 88 patients (80.7%). Additional appointments were predominantly related to the third appointment: assessment of esthetics and occlusion (n = 17).

The mean number of restorative appointments for completion of the fixed prostheses was 5.3 ± 0.63 and 4.8 ± 0.81 for the early and late groups, respectively ($P < .05$). Mean time for completion of the permanent prosthesis was estimated to 279 ± 28.12 and 163 ± 27.72 minutes, respectively ($P < .05$).

Prosthesis Survival and Maintenance

Two men in the early group lost their fixed prostheses and were recorded as failures because of implant failure after 1.5 and 3 years in function, respectively (Table 2). After exclusion, these patients were provided with removable overdentures supported by the remaining implants. In the late group, none of the fixed prostheses failed. The 5-year fixed prosthesis CSR was 97.1% and 100.0% for the two groups, respectively (Table 2).

Altogether, 17 (22%) and 49 (45%) prostheses were followed without any problems ("no events") or complications needing clinical adjustments reported in their files during the 5-year follow-up period in the early and late groups, respectively ($P < .05$). The corresponding number of patients with "no event," also including withdrawn patients, was 22 (29%) and 68 (62%), respectively.

The distribution of the number of examined patients with regard to the number of clinical appointments per year is presented in Table 3. It can be observed that the mean number of clinical appointments per year was highest during the first year in function. Considering all patients, 11.8 ± 8.67 appointments were used on average to maintain prostheses in the early group up to termination of the study after 5 years, as compared to a mean 5.1 ± 1.46 appointments for the late group ($P < .05$). The corresponding mean values for patients followed for 5 years was 12.8 ± 8.97 and 6.0 ± 1.47 appointments during the 5 years, respectively ($P < .05$, Table 4).

Temporary removal of the screw-retained prostheses was frequently used in both groups to handle complications and problems during the follow-up period (Table 5). Fewer prostheses were removed for adjustments in the late group, indicating lower levels of problems in this group (Table 5). Most problems were related to diction, veneer fractures, and mucosal inflammation at the implants, while mechanical problems related to the implant components were few (Table 5).

Table 2 Life Table of Prostheses in the Early and Late Groups of Patients

	Early				Late			
	Patients	Dropout	Failure	CSR (%)	Patients	Dropout	Failure	CSR (%)
Prosthesis	76	0	0	100.0	109	0	0	100.0
1 y	73	3	0	100.0	107	2	0	100.0
2 y	71	1	1	98.6	93	14	0	100.0
3 y	68	3	0	98.6	91	2	0	100.0
4 y	64	3	1	97.1	84	7	0	100.0
5 y	62	2	0	97.1	84*	0	0	100.0
Total	62	12	2	97.1	84*	25	0	100.0

CSR = cumulative survival rate.
*Two patients were examined only clinically after 5 years, without radiographs.

Table 3 Mean No. of Clinical Visits per Patient During the Follow-Up Period

	Early					Late				
	1 y	2 y	3 y	4 y	5 y	1 y	2 y	3 y	4 y	5 y
Patients	73	71	68	64	62	107	93	91	84	84
Mean*	6.0	4.8	2.3	4.7	1.5	2.5	2.1	1.5	1.9	1.2
Standard deviation	3.60	3.23	2.72	2.72	1.48	1.77	1.42	1.47	1.47	0.82
Maximum	25	16	16	11	8	12	6	9	6	7

*Patients with no events were also followed on a regular basis—accordingly, they were included in mean calculations even though they had no problems or adjustments.

Table 4 Distribution of Patients with Regard to No. of Visits/Year

	Early					Late				
	1 y	2 y	3 y	4 y	5 y	1 y	2 y	3 y	4 y	5 y
No visits	0	48	0	43	0	1	64	24	65	0
1–2 visits	1	4	50	5	55	86	19	59	14	81
3–5 visits	38	14	12	10	4	13	9	6	4	2
6–8 visits	21	3	3	4	3	5	1	1	1	1
9–12 visits	10	1	2	2	0	2	0	1	0	0
> 12 visits	3	1	1	0	0	0	0	0	0	0

Discussion

The early and late groups of patients were characterized by different experiences of edentulism.[14] Patients in the early group seemed to have lost their teeth in an earlier period of life and therefore had been edentulous for a longer period before implant treatment. Since implant treatment was not a wide-spread, established protocol during the mid-1980s, patients in the early group waited for a longer time period before eventually being treated. With the feeling of being "pioneers" in implant treatment, these patients were more compliant for recall visits, and significantly fewer patients were lost to follow-up because of poor compliance. Similar patterns in early implant groups have been reported by others.[6,21]

No significant improvement with regard to the number of additional clinical appointments during prosthetic treatment was observed between the two groups, ie, there seemed to be a consistent need for esthetic re-evaluation of tooth arrangements in both groups. However, both mean number of clinical appointments and total clinical chair time were significantly improved in the late group ($P < .05$). Thus, with similar prosthetic protocols and materials used in the two groups, experience and improved logistics in the clinic seem to have the impact of reduced clinical time. The use of custom-made trays in the early group was changed to the application of standard trays. This modification in impression technique did not seem to influence the clinical outcome in the present study. Supportive in vitro findings demonstrated that the

Table 5 Patients with Clinical Problems (No. of Patients at the Termination of the Study) Reported During the Follow-up Period

	Early (n = 76 [62])	Late (n =109 [84])	Difference*
No event	22 (17)	68 (49)	$P < .05^{\dagger}$
Diction	22 (19)	4 (3)	$P < .05^{\dagger}$
Fractures			
Resin veneers	26 (23)	17 (15)	$P < .05^{\dagger}$
Implants	0 (0)	0 (0)	
Abutment/gold screws	0 (0)	0 (0)	
Framework	2 (2)	1 (1)	
Implant failures	20 (15)	13 (11)	$P > .05$
Loose abutment/gold screw	3 (3)	1 (1)	
Mucosa-related			
Hyperplasia/inflammation	22 (19)	14 (14)	$P > .05$
Fistulas	11 (11)	0 (0)	
Prosthesis-related			
Adjustment/redesign	15 (15)	16 (14)	
Gingival prosthesis	6 (4)	0 (0)	
Remake of prosthesis	0 (0)	0 (0)	
Temporarily removed prosthesis	47 (40)	29 (25)	$P < .05^{\dagger}$
TMD problems	3 (3)	2 (2)	

TMD = temporomandibular disorder.
*Differences were calculated using total number of patients (n = 76/n = 109).
†Statistically significant.

accuracy in abutment position in a cast model duplicated from a five-abutment model was similar using both stock and custom-made trays.[22] Thus, a consistent impression procedure with similar impression materials and techniques over the years has proven to be accurate and predicable.[18] The only major modification of the prosthetic protocol was related to the framework design, where the Procera technique improved precision of fit.[23] This has allowed for reduction of clinical appointments but seems to have no significant impact on the long-term function of the restorations.[19,24] The longer time period from stage-two surgery to completion of the prosthesis can be explained by the closing of the dental laboratory in the clinic, resulting in longer transportation time for the laboratory works and the fabrication of the milled framework as compared to a cast framework, which is fabricated close to the clinic.

Clinical results in the present study reflect an increased clinical experience, observed in both shorter clinical time for prosthesis fabrication as well as in significantly fewer complications and shorter and fewer postinsertion visits during the follow-up period (Tables 3 to 5). Accordingly, it is reasonable to assume that clinicians who begin using implants today are not on the same experience level as more experienced teams after long-term use of the technique. Since most clinical publications are based on data from university clinics and "specialist teams" worldwide, the differences between experienced and unexperienced teams may be greater today than 15 to 20 years ago. The consequences of this could be that there is an obvious lack of knowledge on the clinical performance of implant treatment in the average situation today, where more general dentists with relatively less experience are responsible for a major portion of implant treatments. Accordingly, there is a need for more studies performed in general dental clinics with more variation of clinical experience.[25,26]

The present study indicates that several changes have taken place in clinical practice over the years. Older and less compliant patients with shorter healing periods before implant placement are some of these factors that may have an impact on treatment results in the edentulous maxilla. Also, the trend of designing prostheses with better esthetics by using clinically shorter abutments and placing prostheses closer to the mucosa (see Figs 1 and 2) may change the maintenance of the prostheses significantly during the follow-up period (Table 5). Accordingly, significantly fewer patients reported diction problems after placement in the late group ($P < .05$), but still, a trend of improved mucosal health can be observed (Table 5).

Conclusions

It can be observed in the present study that the overall clinical treatment and follow-up situation has shown obvious improvements over the years, and less time is spent both in the treatment as well as maintenance phases. Much of this can be related to improved and better clinical techniques, but the experience of the clinicians is judged to have a major impact on the improved results.

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