Mandibular Implant Overdentures Followed for Over 10 Years: Patient Compliance and Prosthetic Maintenance

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> **Purpose:** The mandibular implant overdenture is a popular treatment modality and is well documented in the literature. Follow-up studies with a long observation period are difficult to perform due to the increasing age of patients. The present data summarize a long-term clinical observation of patients with implant overdentures. Materials and Methods: Between 1984 and 1997, edentulous patients were consecutively admitted for treatment with an implant overdenture. The dentures were connected to the implants by means of bars or ball anchors. Regular maintenance was provided with at least one or two scheduled visits per year. Recall attendance and reasons for dropout were analyzed based on the specific history of the patient. Denture maintenance service, relining, repair, and fabrication of new dentures were identified, and complications with the retention devices specified separately. **Results:** In the time period from 1984 to 2008, 147 patients with a total of 314 implants had completed a follow-up period of > 10 years. One hundred one patients were still available in 2008, while 46 patients were not reexamined for various reasons. Compliance was high, with a regular recall attendance of > 90%. More than 80% of dentures remained in continuous service. Although major prosthetic maintenance was rather low in relation to the long observation period, visits to a dental hygienist and dentist resulted in an annual visit rate of 1.5 and 2.4, respectively. If new dentures became necessary, these were made in student courses, which increased the treatment time and number of appointments needed. Complications with the retention devices consisted mostly of the mounting of new female retainers, the repair of bars, and the changing of ball anchors. The average number of events and the rate of prosthetic service with ball anchors were significantly higher than those with bars. Twenty-two patients changed from ball anchors to bars; 9 patients switched from a clip bar to a rigid U-shaped bar. Conclusions: This long-term follow-up study demonstrates that implant overdentures are a favorable solution for edentulous patients with regular maintenance. In spite of specific circumstances in an aging population, it is possible to provide long-term care, resulting in a good prognosis and low risk for this treatment modality. For various reasons the dropout rate can be considerable in elderly patients and prosthetic service must be provided regularly. Int J Prosthodont 2010;23:91-98.

There have been discussions in the literature on whether treatment for complete edentulism will disappear¹ and if there is still a need for complete dentures. So far it seems that complete edentulism is often present in elderly patients, but has been postponed gradually to older age. This may become a dilemma for the dentist and patient. Providing complete dentures is difficult, particularly if the capacity of adaptation and motor skills of the patient are impaired and teeth are lost only as a result of old age.

Studies on the placement of interforaminal implants in complete denture wearers go back to the 1980s and early 1990s.^{2–5} In the period when overdentures were first developed, the number of implants placed and the type of retention mechanism

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were discussed controversially. Two single-standing implants with ball attachments were sometimes considered a risk, and still today, four implants splinted by a bar are recommended or preferred.^{6,7} However, a better treatment outcome was not observed with four implants.⁸ The two-implant treatment modality has become increasingly popular within the past 20 years and is now well established and documented. It is even considered by some clinicians to be the standard of care.⁹ One recent study suggested that tooth roots for overdenture support may become obsolete since clinical findings on implants are promising and favorable.¹⁰

The primary focus of early clinical studies was the survival of implants and oral hygiene. More recently, prosthetic maintenance, including economic aspects, became the focus of various studies, and complications with mandibular implant overdentures, comparison of retention devices, maintenance of overdentures, and costs have been investigated.¹¹⁻¹⁶ The impact of mandibular implants on satisfaction, function, and well-being compared to wearing complete dentures has also been analyzed.¹⁷⁻²⁰ These studies document successful treatment outcomes and better oral health-related quality of life. However, there are also concerns by clinicians and caregivers that providing adequate aftercare may be difficult or impossible in aging patients, particularly if they become dependent and frail.

Long-term data (> 10 years of observation) are not easily collected due to the specific life circumstances of ageing patients, and dropouts may reach 50% before a 10-year period is completed.²¹ So far only a few studies are available with results of up to 10 years.^{13,15,22-24}

In the present study, edentulous patients with mandibular implants who were included in a regular maintenance program were followed for 10 and up to 24 years. The aim of this long-term data collection was to analyze patient compliance, dropouts, and prosthetic maintenance service, including complications with the retention devices of the mandibular overdentures.

Materials and Methods

Patients and Implants

In the period between 1984 and 1997, completely edentulous patients were consecutively admitted for treatment with complete maxillary dentures and mandibular implant overdentures. The data of 147 patients (45 men, 102 women) who had a follow-up time of 10 to 24 years with regular recall attendance were analyzed in this study. The average age of the patients was 62 ± 9.8 years at the time of implant treatment. In most cases, two implants were placed in the interforaminal position. Three implants were placed in 20 patients who had a highly reduced bone height (6-mm implant length) or a narrow curved anterior arch.

The majority of patients received a soldered gold bar; a few patients received ball anchors for fixation of the mandibular dentures. All patients were in fair condition when the implants were placed. Exclusion criteria were as follows: irradiation or chemotherapy, long-term intake of steroids, history of recent heart attack, psychiatric problems, unrealistic expectations of the patients, and insufficient jaw bone to accommodate two implants of a minimum 6-mm length.

All implants placed were Straumann. In the beginning of this research period, the first generation of Straumann implants, ie, one-piece hollow-cylinder implants (type-F), were used. Starting from 1988 onward, two-piece implants became available and subsequently, a few two-part hollow-cylinder and mostly two-part full-screw implants were placed. A nonsubmerged, single-stage technique was performed according to the standard surgical procedure. During the implant healing period of 3 months, patients could only wear dentures that were relieved at the inner surface to avoid any inadvertent loading of the implants. The surgical and prosthodontic treatment was performed by one clinician or under her supervision. Patients covered the entire cost for treatment and maintenance services themselves.

Prosthodontic Treatment

The prosthodontic treatment followed two different protocols.

Protocol 1. Fabrication of the dentures preceded implant surgery. Patients wore the new dentures for 6 months and then implants were placed. After the healing period, a rebasing impression was taken using transfer copings and a master cast was obtained. Either ball anchors were mounted to the implant analogs or a soldered gold bar was fabricated. Then, the denture was rebased and the corresponding female retainers mounted to the housing in the denture base. This procedure was applied if the patient was reluctant to have implants placed and a test period with a new complete denture was suggested before final decision-making.

Protocol 2. Implants were placed in the planned positions and the old existing dentures were adapted to allow an unloaded healing period of 3 months. Then, new dentures were fabricated and completed together with the retention device, ie, either single ball anchors or a connecting bar.

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Fig 1 Radiographs of patients with (a) one-part hollow-cylinder (type-F) implants with a bar, (b) one-part hollow-cylinder (type-F) implants with ball anchors, (c) two-part full-screw implants with a bar, and (d) two-part full-screw implants with retentive anchors (Dalla Bona).

Fig 2 Clinial photographs of patients with (a) a round clip bar on one-part hollowcylinder (type-F) implants, (b) ball anchors on one-part hollow-cylinder (type-F) implants, (c) a rigid U-shaped bar with distal extensions on two-part full-screw implants, and (d) retentive anchors (Dalla Bona) on two-part full-screw implants.



Prefabricated gold copings and gold bar segments were available to solder the bars for both one-part and two-part implants. From 1984 to 1987, custom made titanium ball anchors of 3.5-mm diameter and plastic matrices had to be used in combination with the type-F implants since prefabricated ball anchors (retentive anchors, Dalla Bona) were not available for this implant. Later, when two-part Straumann implants were placed, prefabricated Dalla Bona anchors could be mounted to these implants. The horizontal diameter of the Dalla Bona anchor was 2.25 mm, with a height of 1.9 mm. The neck of the Dalla Bona anchors, which penetrated the soft tissue, was selected according to the thickness of the soft tissue. The round clip bar (Ackermann) had a diameter of 1.9 mm and prefabricated clips of 3.5 mm in length. The rigid bar (U-shaped Dolder bar) had a

height of 2.3 mm and a width of 1.6 mm. The female retainers were extended along the entire bar segment. Short distal extensions were added with a maximum length of 6 mm. The initial cost for overdenture treatment with ball anchors was slightly lower than that with soldered gold bars.

If prosthetic treatment preceded implant installation, the technical procedure to build in ball anchors was facilitated rather than that for bars. All overdentures were reinforced with a simple metal framework to prevent denture fracture. When patients started to wear the implant overdentures, 35 patients received ball anchors, 74 received round clip bars, and 38 received a rigid U-shaped bar with parallel walls. Figures 1and 2 show radiographs and clinical photographs of the different implant types with either bars or ball anchors.

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Table 1 Patients Who Dropped Out

Reasons for dropping out	No. of patients
Death	26
Geriatric hospital	12
Abroad	0
Unknown	5
Private practitioners (moved away)	3
Total	46

Follow-up and Data Collection

When treatment was completed, all patients were scheduled for regular recall appointments two times a year. The dental hygienist was responsible to organize and perform the recall appointments under supervision of the dentist. During the recall session, hygiene and peri-implant tissues were examined and fit of dentures checked. The implants and dentures were cleaned and motivation for adequate home care was reinforced. Minor prosthetic service was simultaneously performed by the dentist, such as tightening of the bar screws and female retainers or removal of sore spots. If complications with implants and retention devices or a major need for prosthetic maintenance was identified that required collaboration with the laboratory technician, patients were scheduled for an additional appointment with the dentist.

Recall Attendance and Dropouts. Participation at scheduled recall appointments was regularly registered and reasons for final dropouts were noted if possible. The overall recall attendance was expressed by the percentage of patients who attended their scheduled maintenance visit at least once or twice a year during the entire follow-up period. Furthermore, specific prosthetic treatment needs, unscheduled visits, and missed or canceled appointments were recorded in the patients' charts. Some patients were no longer available for regular recall visits, but an attempt was made to reach their family members or caregivers by telephone.

The total number of visits to the dental hygienist and the dentist, the average number of visits per year and per patient, and the annual visit rate were all calculated.

Prosthetic Maintenance. In the context of the present study, data from major prosthetic maintenance service were reported. These complications were detected or reported by the patient at the annual or biannual visits, but could not be solved during the regular recall sessions. These patients received separate appointments with the dentists. In case of complications occurring between scheduled recall sessions, the patients contacted the dentist

directly. Prosthetic maintenance was considered to be an objective treatment need that had to be carried out to maintain proper function. Need for proshetic maintenance was categorized as pertaining to either the retention devices or the dentures themselves as follows:

Prosthetic maintenance of retention devices:

- Change from ball anchors or a clip bar to a U-shaped bar
- Repair of fractured bars, change of implant abutments underneath the bar, or placement of new ball anchors
- Change of loose, broken, and lost matrices of bars or ball anchors

Prosthetic maintenance of the dentures:

- Major changes: Rebasing, occlusal adjustment, and repair of dentures; this also included mounting of new teeth on maxillary or mandible dentures
- Fabrication of new dentures in the maxilla or mandible if adjustments or repairs were not possible and costs would exceed or equal that of new dentures

Those patients receiving new dentures during the follow-up period were treated mostly in student courses to lower the costs.

Statistical Analysis

Data were subjected to statistical analysis using SPSS 17.0 (SPSS). Descriptive statistics were used for patients' demographics, calculation of the total number of events for prosthetic maintenance service, the average number of events per denture, and calculation of visits to the dentist and dental hygienist. The annual prosthetic maintenance rate and visit rate per year to the dentist and dental hygienist were analyzed for different retention devices from censored data. Some patients changed the retention device but remained in the original group according to the intent of treatment. The Mann-Whitney *U* test was applied for testing differences between retention groups.

Results

One hundred forty-seven patients (102 women, 45 men) with a total of 314 implants completed a followup period of \geq 10 years, which resulted in a mean observation time of 16.5 ± 3.9 years. The mean age when patients were last seen was 78 ± 9.3 years; 69 patients were over 80 years old and 11 over 90 years old. One hundred one patients were still available for recall in the year 2008. At this time, 6 patients were

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Table 2 Overall Prosthetic Maintenance

	No. of dentures		No. of events*				
	Balls	Bars	Total	Balls	Bars	Total	
Mandible (no. of dentures)	35	112	147	35	112	147	
Maintenance: dentures							
Major changes, repair	27	62	89	38	99	137	
New denture	14	13	27	17	13	30	
Same denture in situ	21	100	121				
Maintenance: retention							
Balls or clip bar to rigid bar	22	9	31				
New balls, repair bars	9	35	44	22	59	81	
Change/repair matrices	21	51	72	53	89	142	
Maxilla (no. of dentures)	35	112	147	35	112	147	
Maintenance: dentures							
Major changes, repairs	16	65	81	35	107	142	
New denture	8	13	21	10	17	27	
Same denture in situ	27	99	126				

*Total number of events: mandible = 390 (balls = 130, bars = 260), maxilla = 169.

living in a nursing home but in rather fair condition and could be brought to the recall visit. Forty-six patients could not be reexamined because of bad health conditions or impaired mobility and they therefore did not wish to visit the dentist, or they had passed away. Table 1 gives an overview on specific circumstances of dropout patients. Only a few canceled or missed appointments were recorded during the entire observation period, mostly caused by health problems or frailty.

For some frail patients, the contact to the geriatric hospitals could be established by telephone and for one of these patients, who suffered from dementia, a change in the oral condition was reported. This patient was brought to the clinic and one implant had to be removed.

The overall recall attendance was 93.4%, meaning that 93.4% of patients had participated in the scheduled visits to the dental hygienist once or twice per year during their entire individual follow-up period. The remaining patients did not drop out on their own; other factors influenced the loss of these patients.

Altogether, 12 implants had to be removed in seven patients (three men, four women) during the individual observation periods. Most patients received new implants and one patient who lost both implants was given a complete denture. Survival of implants, analysis of failures, and radiographic measurements will be published elsewhere.

The survival of prostheses in the year 2008 was over 80%; 82% of the original mandibular and 85% of the original maxillary dentures were still in function. New dentures with the same design were made because of advanced wear, discoloration of the teeth or denture base material, and decrease of the vertical dimension of occlusion. Over the course of the observation period, 22 patients with ball anchors and

Table 3	Average Number of Events Per Patient and
Denture	

	Overall	Bars	Balls	Р
Patient Mandible and maxilla	4.01 ± 2.82	3.50 ± 2.95	5.60 ± 2.79	<.05
Denture Mandible Maxilla	$\begin{array}{c} 2.86 \pm 2.3 \\ 1.08 \pm 1.0 \end{array}$	2.37 ± 2.1 1.26 ± 1.1	$4.43 \pm 2.2 \\ 0.93 \pm 0.9$	<.01 NS

NS = not significant.

9 patients with a clip bar changed to a U-shaped bar and as a consequence, the dentures needed major adjustments or were remade. For 23 mandibular dentures (15%) and 57 maxillary dentures (39%), neither prosthetic maintenance service nor renewal was needed throughout the entire observation time. The observation time up to the first major complication was (time range):

- Repair, change matrices: 2 months to 6 years
- New balls, repair of bars: 5 months to 6 years
- Change of clip bars and ball anchors to rigid bars: 2 to 11 years
- Major change, repair of denture (maxilla): 4 to 15 years
- New denture (maxilla): 7 to 21 years
- Major change, repair of denture (mandible): 4 months to 5 years
- New denture (mandible): 3 to 18 years

Table 2 gives an overview of prosthetic maintenance specified for dentures and with all events listed. In Table 3, the average number of events per patient and denture was calculated, which resulted in statistical differences between bars and ball anchors.

Table 4 Bars Versus Ball Anchors

	Bar	Ball anchors	Р
No maintenance: maxilla (57 dentures)	36%	45%	NS
No maintenance: mandible (23 dentures)	19%	2.9%	<.05
Total maintenance rate	0.25 ± 0.20	0.37 ± 0.14	<.05
Maxillary denture	0.07 ± 0.08	0.05 ± 0.07	NS
Mandibular denture	0.08 ± 0.08	0.09 ± 0.05	NS
Retention devices	0.09 ± 1.0	0.16 ± 0.10	<.01
Mandible total	0.17 ± 0.15	0.25 ± 0.12	<.05
Visit rate: dental hygienist	1.58 ± 0.44	1.42 ± 0.36	NS
Visit rate: dentist (overall)	2.40 ± 0.88	2.55 ± 0.95	NS

NS = not signficant.

The overall number of appointments with the dental hygienist and dentist was 3,360 and 5,375, respectively. This resulted in a median of 22 visits to the dental hygienist and 33 to the dentist, and an annual visit rate of 1.5 ± 0.43 and 2.4 ± 0.9 , respectively. The annual visit rate to the dentist for patients who received new dentures was significantly higher compared to patients who kept the same denture during the entire observation time (2.96 \pm 0.9 versus 2.28 \pm 0.81, *P*<.001).

Table 4 gives a comparison of the annual prosthetic maintenance rate and visit rate in relation to the retention device, eg, ball anchors or bars. There was a statistically significant difference between barand ball-retained overdentures, with more prosthetic maintenance service provided for ball anchors.

Discussion

When the first patients were recruited for the placement of two interforaminal implants, no studies were available that gave clinical information and scientific background regarding this treatment modality. From a clinical and research point of view, it is interesting to gather data on a specific treatment modality during a long period of time, but there are also limitations in the significance of the results. The few patients treated throughout the first 3 to 4 years may represent a learning curve, and over the course of time, criteria of patient selection, implant design, and materials used for prosthesis fabrication have changed continuously. Clinical experience increased over time and this might have influenced the consecutive treatment of the patients in some way, but this is difficult to measure.

The results show that long-term aftercare is possible in an aging population and compliance was high. Reasons for dropouts or losses from the recall program were mostly known. During an extended time period, life circumstances of elderly patients may change suddenly; some patients moved to another city, some patients became completely dependent and moved to a nursing home, and some patients died.

In the 1980s, implant placement was not yet a frequent, popular, or well-known treatment option. Particularly, patients who received implants in this early period believed in the importance of regular maintenance and did not drop out unless they had become frail or passed away. This behavior could be observed in the present study, which exhibited a high recall attendance. Initially, a 6-month recall interval was considered necessary. Subsequently, patients who exhibited good oral conditions over several years were then scheduled only once a year, and this became the standard for regular aftercare. Regular and professional hygiene procedures were considered necessary for many patients, as claimed by other authors.²⁵ But it was also observed that implants remained healthy during a long observation period^{26,27} because regular advice and support in maintaining good oral hygiene was given. The problem of providing adequate long-term aftercare and maintaining contacts to caregivers is an aspect that will become increasingly important in the future, with a larger segment entering the older population.

The need for maintenance is underestimated by the reported data compared to a prospective randomized controlled trial. Since the patients still felt comfortable, they refused suggested adjustments such as rebasing or the mounting of new teeth and did not want to accrue the costs of maintenance services or new dentures. Otherwise, there was not a lack of aftercare, as the numerous visits to the dentist and dental hygienist demonstrate, but strict parameters to provide service could not always be followed at each examination.

Altogether over 80% of the original dentures remained in function > 10 years. The prosthetic plan, ie, implant-supported overdentures, was maintained

in all but one patient who changed to a complete denture. In the latter sense, the survival rate of the mandibular overdentures would amount to > 99%. The maintenance rate was accordingly quite low, with a statistically higher rate for patients with ball anchors. An early study² that included the first patients treated with implant overdentures in the mid-1980s found that ball anchors caused a higher need for maintenance. The selection of the retention devices was not based on good scientific evidence, and stringent conclusions with regard to neither crestal bone resorption nor maintenance service could be drawn,^{22,27-30} One study reported that maintenance service for ball anchors appeared to be higher than for a bar connecting two implants, and no advantage was observed with four implants and a connecting bar.31 Otherwise, better scores for prosthetic maintenance after a 10-year period with ball anchors compared to bars or magnets were reported.^{27,32} Change of ball anchors or clip bars to a rigid bar were described in a previous study with a longitudinal observation of 5 to 15 years.¹² It appeared that better denture stability and less maintenance was required with U-shaped bars. In fact, controversy exists in the literature between the performance of bars and ball anchors, but it has to be taken into account that studies usually report on clip or eggshaped bars and not on rigid bars, as was done in the present study. This may also explain differences in the results.

Cost calculations were done in various studies for both initial costs and the subsequent costs for aftercare.^{16,31,33} However, the health care system is different in different countries, and in countries where denture treatment is financially supported by third parties and insurances, there may be a trend to perform more service or to deliver new dentures more frequently. Additionally, socioeconomic circumstances and a psychologic background often determine the patients' needs and demands. All this converges into a pool of factors that influence decision making for treatment.³⁴ One study reported lower costs for implant overdentures compared to fixed prostheses,33 while some authors suggested that maintenance costs for fixed dentures were lower than those for implant overdentures.³⁵ In the present study, the total number and annual rate of patients' visits is listed, which is an indirect way to express the investment of time and subsequently, costs for aftercare. The visit rate was rather high. Since new dentures were mostly made in student courses, this increased the treatment time with many additional appointments and contributed to a high visit rate. This could lead to an overestimation of costs.

Conclusions

This long-term follow-up study demonstrates that regular professional care can be provided for an aging population with implant overdentures, resulting in a good prognosis and low risk of failure for this treatment modality. Implant losses are not frequent and denture survival is high, but regular maintenance must be provided and may result in a considerable visit rate.

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