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ORIGINAL ARTICLE

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Mandibular implant-supported overdentures in (frail) elderly: A prospective study with 20-year follow-up

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Abstract

Purpose: To prospectively assess long-term (20 year) clinical, radiographic, and patient-reported outcomes of an elderly population provided with mandibular implant-supported overdentures.

Materials and Methods: A total of 53 elderly (aged ≥60 years at the time of treatment) were provided with two endosseous implants supporting a mandibular overdenture and a conventional maxillary denture. Outcome parameters—including implant loss, plaque index, gingival index, bleeding index, presence of calculus, probing depth, and satisfaction with implant-supported overdenture—were scored 1, 5, 10, and 20 years after prosthetic treatment. Radiographic analysis was performed to assess peri-implant bone changes. At the 20-year evaluation, frailty (Groningen Frailty Index) and quality of life (EuroQol 5D) were additionally assessed.

Results: A total of 15 patients completed the 20-year follow-up. The 20-year implant survival rate was 92.5%. Plaque index, bleeding index, and probing depth increased slightly over time, while gingival index and presence of calculus remained unchanged. Radiographic analysis revealed minor marginal bone loss during the first 10 years and no further loss thereafter. Participants were very satisfied with their prosthesis and reported a good quality of life. At the 20-year evaluation, 64.3% of the patients were classified as frail.

Conclusions: The long-term survival of implants supporting a mandibular overdenture is high. Although most elderly in the study became frail over time, peri-implant health and marginal bone level remained at a satisfactory level.

KEYWORDS

aging, dental implants, elderly, gerodontology, implant-supported overdenture, quality of life

1 | INTRODUCTION

Over time, the majority of the edentulous patients provided with conventional dentures experience functional problems with their mandibular dentures. They often report lack of stability and retention, as well as decreased chewing ability.[1] Patients with these problems can benefit from endosseous implants in the mandible. Placement of two dental implants to support a mandibular overdenture increases stability and retention and consequently improves chewing ability and bite force.[2–4] Patients provided with a mandibular implant-supported

overdenture show improved masticatory function, a better quality of life and are generally very satisfied with their overdenture.[4–8]

Placement of dental implants to support a mandibular overdenture is regarded a safe and predictable treatment. However, little is known about the long-term results (≥10 years of follow-up) of implant-supported mandibular overdentures, especially in elderly who become frail over time. The latter is of great importance as the number of elderly with implant-supported overdentures is rapidly increasing.[9]

Along with the process of human aging, a decline in oral health can be expected, as the increase in cognitive and physical disabilities in frail elderly can lead to poor oral hygiene.[10–12] In addition, frail elderly usually visit the dental office less frequently due to immobility and cognitive decline.[11,13] Multimorbidity and polypharmacy, common in frail elderly, may also lead to xerostomia and hyposalivation.[14] This can cause oral health problems such as impaired oral comfort and loss of teeth due to tooth decay, which in turn can lead to masticatory problems and oral pain. All these factors contribute to deteriorating oral health and declining quality of life.

Poor oral hygiene is presumed to be a severe risk for peri-implant health, leading to chronic inflammation and ultimately to loss of implants and loss of oral function.[15–17] However, it is still unclear whether the age-related decline in general and oral health has an impact on peri-implant health in the elderly patients. Therefore, this study aimed to prospectively assess the long-term (20 years) outcomes of implant-supporting mandibular overdentures in an elderly population aged >80 years at the time of the last follow-up visit. The clinical outcomes included implant survival, bleeding index, and marginal bone loss, and the patient-reported outcomes included patient satisfaction and quality of life at the 20-year evaluation.

2 | MATERIALS AND METHODS

2.1 | Patient selection and treatment

Patients enrolled in this study originated from the previous prospective trials of Heijdenrijk et al. and Batenburg et al.[18–20] The short-term, medium-term, and long-term results (≥10 years) of these studies have been reported previously.[21–24] For the present 20-year follow-up study, we included all patients from the studies of Heijdenrijk et al. and Batenburg et al. who were aged >60 years at the time of implant placement. All patients were edentulous at the start of the study and reported lack of retention and stability of their conventional denture. They were subsequently provided with two endosseous implants to support a mandibular overdenture on a bar-clip system. All patients wore conventional maxillary dentures.

Depending on the previous study in which they were enrolled, the participants received various treatments.

Those enrolled in in the study of Batenburg et al.[18] received one of the following treatments:

- Brånemark implant system with a machined surface (Nobel Biocare Holding AG, Zürich, Switzerland);
- Intramobile cylinder (IMZ) implant system with titanium-sprayed surface (TPS) coating (Dentsply Friadent, Mannheim, Germany);
- International team for implantology (ITI) solid screw-implant system with TPS coating (Institut Straumann AG, Basel, Switzerland).

Those enrolled in the study of Heijdenrijk et al.[19,20] received one of the following treatments:

- IMZ cylinder implant system with TPS coating, one- or two-stage placement;
- ITI solid screw-implant system with TPS coating.

Table 1 shows implant characteristics at baseline. Implant placement was followed by a 3-month healing period. New maxillary conventional dentures and mandibular implant-supported overdentures on a bar-clip system were then fabricated by experienced dentists.

Oral hygiene instructions were given on regular basis starting 2 weeks after abutment placement (two-stage implant placement) or 2 weeks after implant placement (one-stage implant placement).

During the first 10 years after implant placement, patients were recalled yearly for dental check-ups in the hospital. Participants were evaluated at baseline (T_0) and at 1 year (T_1), 5 years (T_5), 10 years (T_{10}), and 20 years (T_{20}) after placement of the mandibular overdenture. Characteristics of the group at baseline are listed in Table 2. Bone quality at baseline was assessed according to Lekholm and Zarb on a lateral cephalometric radiograph.[25] Mandibular height was measured on a rotational panoramic radiograph.

Most participants had to be referred to a local dentist after 10 years of follow-up due to physical decline and reduced mobility, which prevented them from traveling to the hospital. If patients were unable to attend to the 20-year follow-up in the hospital, they were visited at home for the evaluation. During the home visits, intraoral radiographs could not be made.

The Groningen Medical Ethical Committee provided a waiver (file number M17.217679) for this observational study as it was not an experimental study with test subjects as defined in the Medical Research Involving Human Subjects Act. Written informed consent was obtained from all participants, and the study was performed in accordance with the Declaration of Helsinki.

2.2 | Clinical analysis

The following clinical parameters were scored:

- Implant loss: removal or loss of an implant any time after surgery was regarded as implant loss;
- Plaque index: presence of plaque was scored by the *Mombelli plaque index*.[26] as follows: score 0 = no detection of plaque; score 1 = plaque detected only by running a probe across the smooth marginal surface of an implant; score 2 = plaque can be seen by the naked eye; score 3 = abundant soft matter;
- Calculus index: presence of calculus was scored as follows; score 0 = no calculus; score 1 = calculus present;
- Peri-implant health was scored using the following three parameters:

TABLE 1 Implant characteristics at baseline

Study	Implant type	Length (mm)	Diameter (mm)	1 or 2 stage	Number of patients
Batenburg et al.[18]	Brånemark	10-15	3.75	2 stage	13
Batenburg et al.[18]	IMZ	10-15	4	2 stage	7
Batenburg et al.[18]	ITI	10-16	4.1	1 stage	6
Heijdenrijk et al.[19,20]	IMZ	11-15	4	1 stage	8
Heijdenrijk et al.[19]	IMZ	11-15	4	2 stage	7
Heijdenrijk et al.[20]	ITI	10-16	4.1	1 stage	12

- The degree of inflammation of the peri-implant tissue was scored using the *Loë and Silness index*[27] as follows: score 0 = normal gingiva; score 1 = mild inflammation and slight change in color, edema but no bleeding on probing (BOP); score 2 = moderate inflammation with redness, edema, glazing, and BOP; score 3 = severe inflammation with marked redness and edema, ulcerations, or spontaneous bleeding.
- The *Bleeding-index according to Mombelli* [26] scored the presence of bleeding as follows: score 0 = no bleeding when a periodontal probe was passed along the gingival margin adjacent to the implant; score 1 = isolated bleeding spot visible; score 2 = blood forms a confluent red line on the gingival margin; score 3 = heavy or profuse bleeding.
- *Pocket depth* was measured on four sides of the implant (buccally, mesially, lingually, distally) using a periodontal probe (Merit B, Hu Friedy, Chicago, Illinois). Probing depth was defined as the distance between marginal border of the mucosa and the tip of periodontal probe.

2.3 | Radiographic analysis

To analyze bone level over time, standardized intraoral radiographs were obtained using a beam direction device as described by Meijer et al.[28] A digital sliding gauge was used to analyze bone level. The measurements were made along the implant axis from a fixed reference point to the level of bone. Measurements were carried out on mesial and distal side of the implants. The radiographs at 20-year follow-up were compared to baseline radiographs to determine any implant loss.

TABLE 2 Patient characteristics at baseline

Patient characteristics	n = 53
Age in years (median, IQR)	69 (63-72)
Gender (male/female)	22/31
Edentulous period lower jaw in years (median, IQR)	25 (15-36)
Mandibular bone height in mm (median, IQR)	16 (14.5-18)
Median bone quality (score 1-4) (IQR)	3 (2-3)
Total implants placed	106

2.4 | Patient-reported outcomes at the 20-year follow-up

Patients received questionnaires on demographic characteristics including age, marital status, living situation, education, income, and health (underlying diseases, use of drugs). This was followed by questions regarding dental visits, oral hygiene, ability to independently remove their implant-supported overdenture, and satisfaction with the prosthetic device. Satisfaction was scored on a visual analogue scale (VAS) scale ranging 1 to 10. A higher score indicated a higher satisfaction. Patients (and caretakers) were asked if there was any implant loss in the last 10 years.

Validated questionnaires to assess frailty and quality of life were used. Frailty was scored by using *Groningen Frailty Indicator* (GFI).[29] This questionnaire consists of 15 items and determines losses of function in physical, cognitive, social, and psychological domains. The total score ranges from 0 to 15; a score of ≥4 is regarded as frail.

Health-related quality of life was assessed by *EuroQoL-5D* (EQ-5D) and the *EuroQoL VAS* (EQ VAS).[30] This instrument combines five domains: mobility, self-care, pain, daily activities, and psychological status. An index score is determined for every participant; the total score of EQ-5D ranges from 0 to 1, EQ VAS ranges from 0 to 100. A higher score indicates a better quality of life.

2.5 | Data analysis

For the clinical analysis, the worst score of each item per person was assumed to be representative for the status at the time of that evaluation. The radiographic analysis used the worst score per implant as a representative score. Data were analyzed using IBM SPSS Statistics 23 (SPSS, Inc, IBM Company, IBM Corporation, Chicago, Illinois). A significance level of $P < .05$ was chosen. The Shapiro-Wilk test was used to assess normality of the data ($P < .05$). Median and interquartile ranges were provided for the not normally distributed clinical parameters. Mean and SD were used for normally distributed parameters. The Friedman test was used to assess differences in clinical parameters over time (significance level $P < .05$). Post hoc analysis was carried out with the Wilcoxon signed rank test using the Bonferroni correction ($P < .01$). Radiographic analysis was performed using repeated measures ANOVA ($P < .05$) and post hoc the Bonferroni test.

3 | RESULTS

The original study groups of Heijdenrijk and Batenburg consisted of 53 patients in total. All patients were present at T_0. After 1 year, one patient did not attend due to sickness (n = 52). At T_5, five patients did not attend due to sickness and two patients had died (n = 46). After 10 years, four patients had moved without leaving an address, seven did not attend due to sickness, and five patients had died (n = 35). At the T_{20} evaluation, another 26 patients had died and one patient had moved without leaving an address (n = 15). Three patients could not come to the hospital for a general check-up: two patients were homebound and too sick to attend a check-up and one patient could not visit because she was admitted in a nursing home due to severe dementia. At T_{20}, these three patients were therefore visited at home.

Post hoc analysis showed no differences in radiographic and clinical parameters at T_0 and T_1 between the elderly attending at T_{20} and the elderly not attending T_{20} (lost to follow-up) (Table S1). Elderly who attended T_{20} were younger and had a shorter edentulous period at baseline, but bone quality and bone height were comparable to the elderly who did not attend T_{20}.

3.1 | Clinical parameters

During the first 10 years of the study, seven implants were lost. Two of these implants were lost by one patient after 5 years. After 10 years, one implant was lost. Therefore, 8 out of 106 implants were lost during the 20-year evaluation period, resulting in an implant survival rate of 92.5%.

Table 3 provides an overview of the clinical parameters. Significant differences over time were found for the plaque index, bleeding index, and probing depth. Pairwise comparisons showed that plaque scores at T_{20} were significantly higher than at T_0, T_1, and T_5, indicating that oral hygiene had deteriorated. Bleeding index, gingival index, and presence of calculus at T_{20} were comparable to those at baseline, while probing depth had increased slightly.

3.2 | Radiographic analysis

The radiographic analysis of the implants over 20 years is shown in Table 4. Over time, an increase in marginal bone loss was seen during the first 10 years of follow-up, while no further bone loss was seen thereafter.

3.3 | Patient-reported outcomes

Patient-reported outcomes are summarized in Table 5. At the 20 years evaluation, the median age of the participants was 85.5 years. At T_{20}, 64.3% of the elderly were frail (GFI score ≥4). Patient satisfaction with the overdenture was satisfactory, and quality of life (EQ-5D, EQ-VAS) was high. A recent dental visit was reported by 78.6% of the elderly. Almost all (92.9%) subjects brushed their implants and overdenture independently. One elderly could not remove the mandibular implant-supported overdenture herself, but needed help from her husband and homecare providers.

4 | DISCUSSION

This long-term prospective study on mandibular overdentures supported by two implants and a bar-clip attachment in an elderly population (aged ≥80 years at 20-years follow-up) showed high-implant survival and limited changes in peri-implant parameters and marginal bone level, despite deteriorated oral hygiene.

Overall implant survival rate after 20 years of follow-up was 92.5%. This percentage is in line with other studies with a long follow-up. Vercruyssen et al. showed a survival rate of 95.5% after 23 years of loading of two implants supporting an overdenture in the mandible, and Ueda et al. reported a survival rate of 85.9% after 24 years.[31,32] These studies, however, had a retrospective study design and also included patients <60 years. The long-term results might suggest that the longer the follow-up period the more implants are lost, but careful evaluation of literature showed that failure of dental implants mainly occurs soon after placement.[33,34] In our study as well, three out of eight lost implants were lost within the first year after placement.

TABLE 3 Clinical parameters at T_0, T_1, T_5, T_{10}, and T_{20}

Clinical parameters	T_0 (n = 53)	T_1 (n = 52)	T_5 (n = 46)	T_{10} (n = 34)[a]	T_{20} (n = 14)[a]	Significance (*P*-value)[b]
Plaque index (median, IQR)	0 (0;1)	0 (0;1)	0 (0;2)	0 (0;2)	2 (1.75;2)[c,d,e]	<.001
Presence of calculus (median, IQR)	0 (0;1)	0 (0;1)	0 (0;1)	0 (0;1)	0 (0;1)	Not significant
Gingival index (median, IQR)	0 (0;0.5)	0 (0;0)	0 (0;1)	0 (0;0)	0 (0;1)	Not significant
Bleeding index (median, IQR)	1 (0;1)	1 (0;1)	1 (0;1)	0 (0;0)[f,g]	1 (0;2)	.013
Probing depth (median, IQR)	3 (3;4)	3 (3;4)	3 (3;3)	3 (3;3)	3.5 (3;4.3)	.015

[a]One patient lost both implants before T_{10} and was reimplantated. These parameters were excluded.
[b]Statistical difference over time using the Friedman test ($P < .05$).
[c]*P*-value <.01 between T_0 and T_{20}.
[d]*P*-value <0.01 between T_1 and T_{20}.
[e]*P*-value <0.01 between T_5 and T_{20}.
[f]*P*-value <0.01 between T_0 and T_{10}.
[g]*P*-value <0.01 between T_5 and T_{10}.

TABLE 4 Radiographic analysis to determine bone loss

Bone loss	Bone loss between T_0 and T_1 (n = 102)	Bone loss between T_0 and T_5 (n = 90)	Bone loss between T_0 and T_{10} (n = 61)	Bone loss between T_0 and T_{20} (n = 22)	Significance (P-value)[a]
Bone loss in mm (mean, SD)	0.45 (0.7)	0.82 (1.04)	1.20 (1.20)[b]	1.14 (0.85)[c,d]	0.003

[a]Statistical difference over time using repeated measures ANOVA ($P < .05$).
[b]P-value <.05 between change in marginal bone level of T_1 and T_{10}.
[c]P-value <.05 between change in marginal bone level of T_1 and T_{20}.
[d]P-value <.05 between change in marginal bone level of T_5 and T_{20}.

Radiographic analysis showed some marginal bone loss during the first 10 years after implant placement and hardly any additional bone loss thereafter. Several other studies (up to 16 years) have shown comparable or even better scores on preservation of bone level.[31,32,35]

In the present study, plaque scores had increased at the 20-year follow-up. This was expected, as a decline in oral health and difficulties in maintaining oral self-care and hygiene are common in frail elderly.[36] Nearly all elderly cleaned their overdenture and implants themselves, but the high plaque scores on implants and overdentures indicated that cleaning is challenging for them. Other studies showed comparable results: as frailty advances, oral health deteriorates.[34]

In this study, no significant differences regarding plaque scores or other implant parameters in patients who were frail vs patients who were not frail at T_{20}. This could only be studied at the 20-years follow-up in a small group of patients, because frailty was not measured during previous follow-ups. No further detailed information on this subject was provided.

Frailty and quality of life in this study were assessed only at T_{20}. There are two reasons for this. At the beginning of the study, no validated frailty questionnaires were available and all participants were relatively young (60 years of age) and in good health. Their health and functioning declined over the next 20 years.

One of the major benefits of an implant-retained overdenture is the potential to adapt the suprastructure to a patient's needs. When necessary, a bar-clip system can be removed easily and replaced by locators or even healing caps when appropriate, thereby simplifying the oral hygiene routine.[37] This way, elderly may profit as long as possible from their implant-supported overdenture.

TABLE 5 Patient-reported outcomes at T_{20}

Patient-reported outcomes	n = 14
Age (median, IQR)	85.5 (84.8-87.8)
GFI (median, IQR)[a]	5 (1-7)
Frail (GFI ≥4; n, %)	9 (64.3)
Satisfaction (mean, SD)	7 (2.5)
Quality of Life (EQ-5D)[b] (median, IQR)	0.79 (0.45-0.87)
Quality of Life (EQ VAS)[c] (mean, SD)	68.2 (15.4)
Recent dental visit (<1 year ago) (n, %)	11 (78.6)
Independent daily oral hygiene (n, %)	13 (92.9)
Able to remove denture independently (n, %)	13 (92.9)

[a]GFI, Groningen Frailty Indicator.
[b]EQ-5D, EuroQoL 5D.
[c]EQ VAS, EuroQol Visual Analogue Scale.

In this study, the focus was on peri-implant health. Prosthetic care and aftercare was not taken into account for reason that in previous studies from our research group (long-term) care and aftercare was described in detail.[38,39] This also included mucositis and adjustments of prostheses. In those studies, it was shown that the need for prosthetic and surgical aftercare was minor.

When elderly become frail and require complex care they need assistance by caretakers or nurses, but many institutionalized elderly are not cooperative about receiving oral hygiene by others.[40] Nevertheless, the high plaque index and deteriorated oral hygiene we observed in this study did not result in excessive peri-implant bone loss or unfavorable peri-implant parameters. Despite the frailty and deteriorated oral hygiene of the participants, this study shows that the implant-supported overdenture is a durable treatment option and that it contributes to a high quality of life. A possible qualification is that most elderly in this study continued to visit their dentist on a yearly basis, which might be an important factor in preventing severe peri-implantitis.

5 | STRENGTHS AND LIMITATIONS

The strength of this study is the long follow-up period in an elderly population with advancing frailty. The main limitation is that many patients died during follow-up. As no differences were found between clinical and radiographic outcomes at T_0 and T_1 for elderly who attended the T_{20} evaluation and those who did not, this study provides credible insight into long-term follow-up of dental implants in an elderly population.

6 | CLINICAL GUIDELINES

When placing dental implants in an aging population aiming to retain an overdenture it should be taken into account that the elderly patient will eventually become frail. In case elderly become frail and care dependent, it may be difficult to maintain a good oral hygiene and visit the dentist regularly. Therefore, we would like to promote the idea that the suprastructures placed can be adjusted or downsized when appropriate. For example, a bar-clip system can be converted into locator-systems when oral hygiene detoriates and dental visits are difficult. Furthermore, dental care professionals should consider home visits when visiting the dental office is not optional anymore. Taken

together this may result in longer preservation of healthy peri-implant tissues and a well-functioning overdenture.

7 | CONCLUSIONS

Despite the deterioration of oral hygiene in elderly with increasing frailty, the long-term (20 years) survival of dental implants supporting a mandibular overdenture is high.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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