Implant-Retained Mandibular Overdentures Versus Conventional Dentures: 10 Years of Care and Aftercare

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Purpose: This 10-year prospective, randomized, clinical trial investigated the treatment outcome of edentulous patients treated with mandibular overdentures retained by 2 endosseous implants compared with conventional dentures in patients with or without vestibuloplasty. ***Materials and Methods:*** One hundred fifty-one edentulous patients (5 groups) with a symphyseal mandibular bone height between 8 and 25 mm participated. Sixty-two patients were treated with an overdenture retained by 2 implants (groups 1 and 3), 59 patients were treated with a conventional denture (groups 2 and 5), and 30 patients were treated with a conventional denture after preprosthetic vestibuloplasty (group 4). Patients who received conventional dentures but preferred implants later on could undergo implant surgery after 1 year of their initial treatment, but were analyzed in their original group. The prosthetic and surgical care and aftercare were scored during a 10-year evaluation period. ***Results:*** One hundred thirty-three patients completed the 10-year follow-up evaluations. Forty-four percent of patients treated with conventional dentures switched within 10 years to implant-retained overdentures, versus 16% of the patients who were treated with conventional dentures after vestibuloplasty. On average, a greater time investment and more treatment sessions were needed in patients treated with implant-retained overdentures compared to patients treated with conventional dentures. ***Conclusion:*** Patients treated with an implant-retained overdenture need more treatment interventions and treatment time than patients treated with conventional dentures.
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Complaints regarding lack of stability and retention of a mandibular denture, together with decreased chewing ability, are common in denture wearers.[1] There is sound evidence that an implant-retained mandibular overdenture significantly reduces these complaints,[2,3] and a mandibular overdenture retained by 2 or 4 endosseous implants has been proposed as routine therapy to treat patients with mandibular denture problems.[4–9]

Most prospective studies with a follow-up of at least 10 years are focused on implant survival rates,[7,10,11] while very few studies evaluate the surgical and prosthetic aftercare.[2,12–14,29] Recently, Goodacre et al[15] reviewed the literature on the clinical complications with implants and implant prostheses and reported a large number of complications, including: loosening of the retentive mechanism (33%), need for relining (19%), implant loss in type IV bone (16%), and overdenture clip/attachment fractures (16%). However, the authors merely compiled the complications reported in the literature (overall total score) and did not relate them to a specific type of treatment. Other publications concerning prosthetic aftercare[13,16–19] are mainly retrospective, with a mean follow-up of up to 5 years. They revealed that prosthodontic and surgical complications are not uncommon in cases of both removable

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and fixed implant-retained prostheses. None of these studies compared the total care and aftercare rate of implant-retained prostheses with the care and aftercare of conventional dentures. They also did not relate the total care and aftercare of a particular treatment option to the overall treatment required. Therefore, the aim of this 10-year prospective, randomized, clinical trial was to evaluate the treatment outcome (prosthetic and surgical care and aftercare related to time investment) of mandibular overdentures on 2 endosseous implants compared with conventional dentures in patients with or without vestibuloplasty.

Materials and Methods

Patient Selection and Treatment

Patients referred to the Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics of the University Medical Center Groningen by their dental or general medical practitioner because of persistent retention problems with their conventional dentures were eligible for inclusion in the present study. The retention problems had to be related to a reduced stability and insufficient retention of their mandibular denture. The patients were informed about 3 different treatment options: overdenture retained by 2 endosseous implants, conventional dentures, or conventional dentures after vestibuloplasty. The method employed to assign patients to the different treatment groups and possible risks were explained to the patients prior to participation in this study. All treatment options were appropriate for the patients who fulfilled the inclusion criteria: absence of medical risks interfering with treatment, a mandibular symphyseal bone height not more than 25 mm and not less than 8 mm as measured at the symphysis on a lateral cephalometric radiograph, no history of preprosthetic surgery, an edentulous period of at least 1 year, and no history of radiotherapy in the head and neck region. The hospital's medical ethical committee approved the study.

Patients were included between 1990 and 1992 and were distributed over 5 groups:

- Group 1: overdenture on 2 endosseous implants with mandibular bone height 8 to15 mm (n = 30)
- Group 2: conventional denture with mandibular bone height 8 to 15 mm (n = 30)
- Group 3: overdenture on 2 endosseous implants with mandibular bone height 16 to 25 mm (n = 32)
- Group 4: conventional denture after vestibuloplasty and/or deepening of the floor of the mouth with mandibular bone height 16 to 25 mm (n = 30)
- Group 5: conventional denture with mandibular bone height 16 to 25 mm (n = 29)

A computerized randomization balancing method was used to allocate patients to either groups 1 or 2 (mandibular bone height 8 to 15 mm) or to groups 3, 4, or 5 (mandibular bone height 16 to 25 mm). The balancing criteria were age, gender, edentulous period of the mandible, number of mandibular dentures made previously, number of years having worn the present mandibular denture, and the symphyseal bone height of the mandible, aiming at an equal distribution of patients over the treatment groups. Table 1 shows the characteristics for all groups during the study period of 10 years. Patients selected for groups 2, 4, or 5 (non-implant groups) had the opportunity to switch to an implant-retained overdenture 1 year after their initial treatment, but were analyzed according to the original group to which they were allocated (intention-to-treat principle). All patients with implants were subjected to a strict oral hygiene regimen. They visited a dental hygienist regularly for oral hygiene inspection. If necessary, oral hygiene instructions were given and/or calculus was removed.

Surgical and Prosthetic Procedures

Treatment of all patients took place in the same department (University Medical Center Groningen, Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics) by 2 experienced oral and maxillofacial surgeons and 2 experienced prosthodontists.

Two implant systems were used for patients in groups 1 and 3. In an equal frequency, 2 IMZ (Intra Mobile Zylinder) implants (titanium plasma sprayed, Friedrichsfeld) or 2 Brånemark (Nobel Biocare) implants were placed under local anesthesia in the interforaminal region of the mandible.[20,21] Computerized randomization was again performed for allocation of the implant system used.

During the 3-month healing period a soft liner was applied in the mandibular denture. After the healing period, the mucosa was thinned and the abutments were placed.

Postoperative treatment consisted of the use of analgesics and mouthrinses with chlorhexidine 0.2% for a period of 2 weeks. According to the protocol, no antibiotics were administered after placement of the implants. Patients were not allowed to wear their mandibular denture while eating for a period of 3 months between the placement of the implants and placement of the abutments.

Two weeks after the second-stage surgery, standard prosthetic treatment was carried out via fabrication of a conventional maxillary denture and a mandibular overdenture attached on an individually made round-shaped bar (Cendres and Metaux) with an Ackermann

Table 1 Group Characteristics for Patients Who Completed Follow-up

No. of patients at start of study	Mean age (y) (range)	Died	Moved	No. of patients who completed 10 years of follow-up	Gender (M/F) of patients who completed 10 years of follow-up
Group 1: two implants, mandibular bone height 8–15 mm					
30	56 (46–83)	1	0	29	7/22
Group 2: conventional denture, mandibular bone height 8–15 mm					
30	60 (53–82)	4	1	25	3/22
Group 3: two implants, mandibular bone height 16–25 mm					
32	59 (41–90)	2	0	30	15/15
Group 4: vestibuloplasty, mandibular bone height 16–25 mm					
30	54 (45–80)	5	0	25	9/16
Group 5: conventional denture, mandibular bone height 16–25 mm					
29	55 (44–88)	5	0	24	9/15
Total					
151	57 (41–90)	17	1	133	43/90

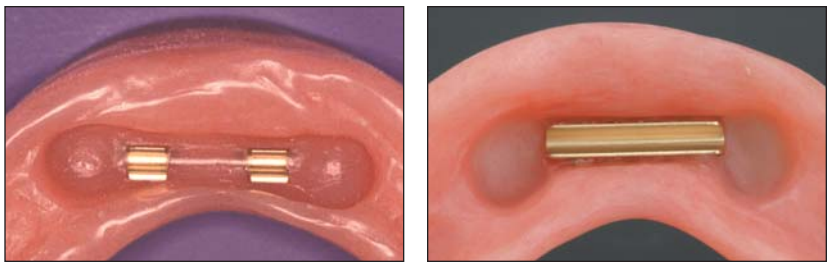

Fig 1 Details of the bases of the overdentures. *(left)* Two Ackermann clips fitted on a round bar. *(right)* Dolder clip fitted on a thick egg-shaped Dolder bar.

clip retention system (Preat) (Fig 1). Bilateral balanced occlusion and monoplane articulation were created for all dentures with porcelain teeth in the anterior and acrylic resin molars in the posterior (Ivoclar-Vivadent). No metal reinforcements were used in the acrylic resin denture base.

Patients in groups 2 and 5 (non-implant groups) received new complete dentures, as did patients in group 4 (vestibuloplasty group), who received new dentures after a vestibuloplasty. Interforaminal vestibuloplasty according to the buccal onlay procedure and lowering of the floor of the mouth were carried out under general anesthesia.[22] After the vestibuloplasty, the prosthodontists waited 4 weeks before manufacturing new dentures. Bilateral balanced occlusion and monoplane articulation with porcelain teeth in the anterior and acrylic resin molars in the posterior were again provided.

Clinical Analysis

From the first day patients visited our clinic until 10 years after the first treatment session, for every visit to the clinic all surgical or prosthetic therapeutic interventions were scored using a standardized score list. All scores were done per day, so if a patient had to revisit the same day (eg, clip repair), it was scored as 1 treatment session. The average treatment time allocated to a particular variable (indicated in Tables 2 to 5) was based on the average treatment time for that variable as indicated by 3 experienced prosthodontists and 3 experienced oral and maxillofacial surgeons. Only chair time was counted. Surgical and prosthetic care and aftercare were scored for 5 well-defined periods.

1. *Pretreatment period* (diagnostic period; all groups): time between first appointment and start of treatment. The variables scored included consultation because of retention problems with the mandibular denture and reconsultation for treatment explanation or planning.
2. *Surgical period* (groups 1, 3, and 4): time from start of the surgical treatment until 2 months after the prosthesis was placed. The variables scored included placement of implants, postoperative care, abutment operation, vestibuloplasty surgery, and softliner application in the mandibular denture. When a soft liner was applied in both the mandibular and maxillary denture it was scored as 2 soft liner applications.
3. *Prosthetic period* (all groups): time from start of prosthetic treatment until 2 months after the prosthesis was placed. The variables scored included fabrication of an implant-retained denture, fabrication of a conventional denture, relief of sore spots, relining of maxillary denture, relining of mandibular denture, grinding occlusion, oral hygiene support, adjustment of occlusion level, and lengthening of the denture base rim.

Table 2 Surgical Period: Mean No. (± SD) of Interventions and Overall Treatment Time Per Patient

Intervention (average treatment time)*	Group 1 (n = 29)	Group 2 (n = 25)	Group 3 (n = 30)	Group 4 (n = 25)	Group 5 (n = 24)
Session for placing implants (45 min)	1.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Session for abutment operation (30 min)	1.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Vestibuloplasty surgery (90 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.00	0.00 ± 0.00
Session for postoperative care (10 min)	4.55 ± 1.78	0.00 ± 0.00	4.93 ± 2.60	4.00 ± 1.35	0.00 ± 0.00
Soft liner application in mandibular denture (15 min)	1.96 ± 1.78	0.00 ± 0.00	2.80 ± 2.77	1.24 ± 1.39	0.00 ± 0.00
Overall treatment time needed per patient (min)	150	0	166	149	0

*In group 4, treatment time is exclusive of hospitalization (average, 3 days).

Table 3 Surgical Aftercare Period: Mean No. (± SD) of Interventions and Overall Treatment Time Per Patient

Intervention (average treatment time)	Group 1 (n = 29)	Group 2 (n = 25)	Group 3 (n = 30)	Group 4 (n = 25)	Group 5 (n = 24)
Consult					
Consult without treatment (15 min)	0.24 ± 0.83	0.92 ± 1.25	0.26 ± 0.64	0.32 ± 0.74	1.00 ± 0.96
Consult with minor treatment (20 min)	0.20 ± 0.94	0.28 ± 0.68	0.03 ± 0.18	0.08 ± 0.40	0.16 ± 0.47
Session for postoperative care (15 min)	0.55 ± 1.08	1.72 ± 2.42	0.33 ± 1.06	0.56 ± 1.12	1.60 ± 1.84
Bacterial biopsy (5 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.20
Implant treatment					
Session for removal of implants (30 min)	0.10 ± 0.31	0.00 ± 0.00	0.17 ± 0.38	0.00 ± 0.00	0.08 ± 0.28
Session for adding implants (45 min)	0.10 ± 0.31	0.40 ± 0.50	0.20 ± 0.41	0.16 ± 0.37	0.46 ± 0.51
Session for placing abutments (30 min)	0.10 ± 0.31	0.36 ± 0.49	0.17 ± 0.40	0.16 ± 0.37	0.33 ± 0.48
Soft tissue treatment					
Palatal grafts (45 min)	0.21 ± 0.14	0.04 ± 0.20	0.07 ± 0.25	0.00 ± 0.00	0.04 ± 0.20
Gingivectomy (15 min)	0.35 ± 0.41	0.04 ± 0.20	0.07 ± 0.25	0.24 ± 0.44	0.00 ± 0.00
Flap treatment (30 min)	0.10 ± 0.31	0.04 ± 0.20	0.07 ± 0.25	0.00 ± 0.00	0.00 ± 0.00
Removal of hyperplasia (15 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.20	0.00 ± 0.00
Local vestibuloplasty (30 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.20
Overall treatment time per patient (min)	41	78	35	31	78

Table 4 Prosthetic Care Period: Mean No. (± SD) of Interventions and Overall Treatment Time Per Patient

Intervention (average treatment time)	Group 1 (n = 29)	Group 2 (n = 25)	Group 3 (n = 30)	Group 4 (n = 25)	Group 5 (n = 24)
Instruction					
Oral hygiene support (15 min)	1.83 ± 0.89	0.00 ± 0.00	2.10 ± 1.37	0.00 ± 0.00	0.00 ± 0.00
Prosthesis					
Fabrication of implant-retained prosthesis (145 min)	1.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Fabrication of conventional prosthesis (125 min)	0.00 ± 0.00	1.00 ± 0.00	0.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
Adjustment of prosthesis					
Relieving pressure sore spot (10 min)	1.44 ± 1.37	1.92 ± 1.25	1.23 ± 1.30	2.56 ± 1.58	2.32 ± 1.46
Relining of maxillary denture (25 min)	0.03 ± 0.19	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.04 ± 0.20
Relining of mandibular denture (25 min)	0.41 ± 0.50	0.00 ± 0.00	0.13 ± 0.57	0.04 ± 0.20	0.04 ± 0.20
Lengthening of denture base rim (20 min)	0.17 ± 0.65	0.00 ± 0.00	0.10 ± 0.40	0.00 ± 0.00	0.08 ± 0.28
Grinding of occlusion (10 min)	0.48 ± 0.57	0.68 ± 0.80	0.37 ± 0.85	0.36 ± 0.56	0.48 ± 0.82
Adjustment of occlusion level (25 min)	0.03 ± 0.19	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Overall treatment time per patient (min)	207	151	198	155	157

4. *Surgical aftercare* (all groups): time from 2 months after the prosthesis was placed until 10 years after treatment was started. The variables scored included session for removal of implants, session for implants added, placement of new implants (in case a non-osseointegrated implant had to be replaced by a new implant), placement of palatal grafts surrounding the implants as additional treatment, gingivectomy, flap treatment of triangle-shaped bone deformities next to the implants, consultation without treatment (concerning problems related to implants), consultation with minor treatment, session for postoperative care (removing sutures, changing abutments, checking wound healing), session for placing abutments, removal of hyperplasia, bacterial biopsy, and local vestibuloplasty.
5. *Prosthetic aftercare* (all groups): time from 2 months after the prosthesis was placed until 10 years after treatment was started. The variables scored included periodic/routine inspections, oral hygiene instruc-

Table 5 Prosthetic Aftercare Period: Mean No. (± SD) of Interventions and Overall Treatment Time Per Patient

Intervention (average treatment time)	Group 1 (n = 29)	Group 2 (n = 25)	Group 3 (n = 30)	Group 4 (n = 25)	Group 5 (n = 24)
Consult					
Routine prevention inspections (15 min)	6.24 ± 2.32	4.28 ± 2.62	4.87 ± 2.51	4.32 ± 2.39	4.50 ± 2.73
Routine inspection after treatment (10 min)	1.62 ± 1.97	1.92 ± 2.43	0.87 ± 1.19	1.36 ± 1.52	2.58 ± 2.16
Complaints without treatment (15 min)	0.52 ± 0.78	0.36 ± 0.64	0.17 ± 0.59	0.56 ± 1.16	0.33 ± 0.64
Consultation for minor complaints (15 min)	0.27 ± 0.53	0.28 ± 0.74	0.20 ± 0.76	0.04 ± 0.20	0.08 ± 0.28
Pain complaints peri-implantitis (20 min)	0.00 ± 0.00	0.04 ± 0.20	0.00 ± 0.00	0.04 ± 0.20	0.00 ± 0.00
Oral hygiene					
Oral hygiene instructions (15 min)	1.14 ± 1.30	1.16 ± 1.91	1.37 ± 1.61	0.48 ± 1.16	1.21 ± 1.38
Removal of calculus (10 min)	1.27 ± 2.00	1.00 ± 3.17	2.33 ± 3.36	1.00 ± 3.17	1.29 ± 2.07
Prosthesis					
Soft liner application mandibular denture (15 min)	0.14 ± 0.35	0.52 ± 1.00	0.03 ± 0.18	0.24 ± 0.66	0.67 ± 1.01
Soft liner application maxillary denture (15 min)	0.24 ± 0.43	0.16 ± 0.37	0.07 ± 0.36	0.12 ± 0.33	0.08 ± 0.28
Repair of denture teeth (15 min)	0.72 ± 1.19	0.48 ± 0.82	1.03 ± 1.54	0.68 ± 1.07	0.50 ± 0.93
Repair of denture base (15 min)	0.65 ± 1.39	0.12 ± 0.33	0.27 ± 0.78	0.36 ± 0.95	0.42 ± 1.44
Relining mandibular denture (25 min)	0.38 ± 0.62	0.24 ± 0.52	0.37 ± 0.72	0.72 ± 0.89	0.42 ± 0.77
Relining maxillary denture (25 min)	0.59 ± 0.78	0.20 ± 0.50	0.40 ± 0.62	0.52 ± 1.04	0.29 ± 0.55
Molloplast relining mandibular denture (25 min)	0.00 ± 0.00	0.36 ± 0.71	0.03 ± 0.18	0.00 ± 0.00	0.29 ± 0.62
Lengthening of denture base rim (25 min)	0.07 ± 0.37	0.04 ± 0.20	0.07 ± 0.25	0.08 ± 0.28	0.00 ± 0.00
Fabrication of new bar (30 min)*	0.34 ± 0.55	0.40 ± 0.57	0.33 ± 0.55	0.20 ± 0.41	0.58 ± 0.65
Fabrication of new mandibular denture (95 min)	0.00 ± 0.00	0.16 ± 0.37	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.28
Fabrication of new complete denture (135 min)	0.21 ± 0.41	0.28 ± 0.54	0.07 ± 0.25	0.24 ± 0.43	0.37 ± 0.57
Grinding of occlusion (10 min)	0.62 ± 0.90	0.44 ± 0.82	0.57 ± 1.10	0.36 ± 0.49	0.33 ± 0.56
Adjustment of occlusion level (30 min)	0.69 ± 0.85	0.28 ± 0.46	0.43 ± 0.57	0.36 ± 0.57	0.25 ± 0.44
Release of sore spots (5 min)	0.65 ± 1.04	1.00 ± 1.26	0.40 ± 0.77	0.40 ± 0.56	0.87 ± 1.07
Session relieving sore spots (10 min)	1.34 ± 2.47	0.92 ± 1.50	0.53 ± 0.94	1.20 ± 1.87	0.54 ± 0.83
New/repair bar or clip					
Repair of loose clips (30 min)	1.93 ± 2.49	0.08 ± 0.28	0.97 ± 1.27	0.32 ± 1.14	1.12 ± 2.31
Repair of bar extension (30 min)	0.03 ± 0.18	0.04 ± 0.20	0.03 ± 0.18	0.04 ± 0.20	0.00 ± 0.00
Replacement of abutments (20 min)	0.03 ± 0.18	0.04 ± 0.20	0.57 ± 2.20	0.00 ± 0.00	0.00 ± 0.00
Activation of clips (5 min)	1.03 ± 1.55	0.00 ± 0.00	0.37 ± 0.76	0.12 ± 0.60	0.17 ± 0.64
Session activating clips (10 min)	0.10 ± 0.31	0.00 ± 0.00	0.10 ± 0.30	0.00 ± 0.00	0.08 ± 0.28
Tightening of loose screws (5 min)	0.62 ± 1.08	0.28 ± 0.74	0.10 ± 0.30	0.12 ± 0.60	0.12 ± 0.34
Overall treatment time per patient (min)	354	250	266	238	306

*Extra time needed to convert a round bar to a thick, egg-shaped Dolder bar with matching clips in the overdenture (groups 1 and 3) or to manufacture a new bar in patients who switched from a conventional denture to an overdenture (groups 2, 4, 5). In the latter patients, only Dolder bars were made.

tions, removal of calculus, repair of loose clips, repair of denture teeth, repair of denture base, fabrication of a new bar, fabrication of a new mandibular denture, fabrication of a new complete denture, adjustment of occlusion level, soft liner application to mandibular denture, soft liner application to maxillary denture, relining of mandibular denture, relining of maxillary denture, molloplast relining of mandibular denture, repair of bar extension, repair of the bar itself, replacement of abutments, grinding of occlusion, complaints without treatment, session activating clips, session relieving sore spots, consultation for minor complaints (eg, complaints about discomfort, sharp teeth, fear of oral pathology, taste problems), release of sore spots during a session other than one for minor complaints, routine inspection after treatment, activating clips during a session other than one for minor complaints, pain complaints, peri-implantitis, tightening of loose screws, and lengthening of denture base rim.

Statistical Analysis

Patients who died or were not able to attend the recall schedule (moved away) during the 10-year evaluation period were excluded from the evaluation study (Table 1). The data were analyzed using *t* tests for the continuous data and Mann-Whitney tests for the ordinal data (SPSS for Windows, version 10.0, SPSS). For all tests a significance level of .05 was chosen.

Other Analyses

In separate studies of the groups included in this study, clinical outcomes as well as various prosthodontic concepts and patient satisfaction were analyzed.[2,23] The main outcome parameters were denture satisfaction and chewing ability, which were assessed using validated self-administered questionnaires focusing on denture-related complaints and problems with chewing different types of food. These parameters were

measured before treatment and 1, 5, and 10 years after treatment. At the 1-year evaluation, significantly better scores were observed in the patients treated with either implants or preprosthetic vestibuloplasty than in the patients treated with a conventional denture. At the 5-year evaluation, the "complaints of the mandibular denture" showed a significantly better score in the implant-retained overdenture group when compared to the vestibuloplasty and conventional denture groups. No significant differences were observed between the vestibuloplasty and conventional denture group. At the 10-year evaluation, intention-to-treat analysis revealed no significant differences between the 3 groups, while a per protocol analysis showed that the implant-retained overdenture group was the most satisfied, as patients in the this group were significantly more satisfied than patients in the conventional denture group after 1 year (satisfaction score of 8.3 versus 6.6 on a scale of 1 to 10), 5 years (7.4 versus 6.4), and 10 years (7.7 versus 6.8).

Results

Patients

Initially, 151 edentulous patients participated in this study. Because of death (n = 17) and moving to other areas (n = 1), a total of 133 patients (90 women and 43 men, mean age 56.8 years, range 44 to 90 years) completed the 10-year evaluation (Table 1). During the 10-year follow-up, significantly more patients switched from conventional dentures to implant-retained overdentures in groups 2 (10 of 25 patients) and 5 (11 of 24 patients) than in group 4 (4 of 25 patients) ($P < .01$).

Pretreatment Period

On average, patients needed 1 session for consultation (20 min) and 1 session for reconsultation (15 min) irrespective of the treatment to follow.

Surgical Care and Aftercare

As expected, patients in groups 1, 3, and 4 needed the most surgical care (Table 2). On the contrary, the most surgical aftercare was given to patients from the non-implant groups (Table 3). Non-implant groups scored high on the following items: implants added (in patients who switched to an implant-retained overdenture), consults without treatment, and sessions for postoperative care.

Seventeen implants were lost, resulting in a 10-year survival rate of 92% for all groups and all implants placed. Figure 2 shows that the majority of implants were lost during the first year after placement. Significantly more implants were lost in patients with a higher bone height in the mandibular symphysis region (group 3; $P < .05$). Lost implants were replaced successfully in all cases.

Prosthetic Care and Aftercare

Patients treated with an implant-retained overdenture needed more prosthetic care than patients treated with a conventional denture ($P < .05$; Table 4). For 15 patients in whom the Ackerman clips frequently broke, the Ackermann bars were replaced by Dolder bars, a system considered more resistant against forces (Fig 1). Relief of sore spots was needed far more often in the mandible than in the maxilla ($P < .01$). The vast majority of sore spots related to the maxilla were seen in patients with a severely resorbed jaw and treated with a mandibular overdenture on 2 implants (group 1). Further, more soft liner applications for the maxillary denture had to be performed in these patients. With regard to the mandibular denture, permanent relining with a soft liner (Molloplast, Detax) was performed significantly more often in patients of groups 2 and 5 ($P < .05$; Table 5). As expected, routine inspections were performed more often in patients treated with an implant-retained overdenture ($P < .05$; Table 5). For all other variables mentioned in Tables 4 and 5, no statistical differences were found when groups 1 and 3 (implant-retained mandibular overdenture) were compared to groups 2, 4, and 5 (conventional denture).

Average Overall Treatment Time

Implant groups scored higher on both number of sessions and treatment time (Table 6). The higher scores with regard to implant treatment are even more striking when performing a per-protocol analysis. In group 2, for example, 44 ± 11 sessions (range 32 to 60) were needed in patients who switched to an implant-retained overdenture, while significantly fewer sessions (18 ± 1, range 12 to 34, $P < .01$) were needed in patients who stayed with their original treatment.

Discussion

Since the 10-year study period included implants placed between 1991 and 1992, some had different designs and surface treatment. This might have contributed to the relatively high rate of implant loss at the start of our study, while our current studies demonstrate a higher implant survival rate.[8,9] Treatment outcome and implant survival were as expected in patients with a mandibular bone height of less than 15 mm, while in patients with a higher mandibular bone height a significant increase in implant loss occurred (Fig 1), similar to the Goodacre et al[15] report. It is suggested that

Table 6 Mean No. (Range) of Sessions and Average Time Needed Per Patient from First Consult to the End of 10-Year Follow-up

	Group 1	Group 2	Group 3	Group 4	Group 5
Mean no. (range) of sessions per patient	43 ± 3 (25–62)	28 ± 24 (12–60)	38 ± 20 (21–58)	32 ± 4 (19–70)	30 ± 2 (13–74)
Average time needed per patient (min)					
Surgical period	150	0	166	149	0
Standard prosthetic period	207	151	198	155	157
Surgical aftercare period	41	78	35	31	78
Prosthetic aftercare period	354	250	266	238	306
Total	752	479	655	573	541

removal of the knife-edge ridge prior to implant placement leads to spongious bone surrounding the neck of the implant, resulting in decreased implant stability.

The IMZ implants used were equipped with intramobile element (IME) connectors[21] that broke often, resulting in frequent visits to our clinic for their easy replacement. Currently, IMEs are no longer used.

All overdentures were initially provided with 2 Ackermann clips. These small clips were subject to fracture or loosening of the retention flanges. Alternative Friatec clips (fitted on the same round bar) were applied when clips fractured repeatedly, or the bar was changed into a thick, egg-shaped Dolder bar with matching clips. The average extra time needed to convert a round bar into a thick, egg-shaped Dolder bar with matching clips in the overdenture was 30 minutes.

Acrylic resin molars were used at the onset of this study. However, during the study many occlusal planes had to be restored because of severe abrasion of these acrylic resin molars, particularly in patients wearing implant-retained overdentures. Acrylic resin molars were replaced by porcelain molars to address this problem.

The fewest number of patients switched to an implant-retained overdenture in the vestibuloplasty group. Thus, vestibuloplasty most likely resulted in sufficient enlargement of the denture-bearing area to increase retention of the mandibular denture in the majority of patients. However, it may not be the long-term solution for retention problems in mandibular dentures in all cases, as during the follow-up about one fifth of patients still switched to an implant-retained overdenture.

Results show that more care and aftercare were given to patients with an implant-retained overdenture compared to patients who received conventional dentures. Owing to the intention-to-treat principle, this difference in care and aftercare does not appear as striking as it really is. A per-protocol analysis showed that patients who switched to an implant treatment needed more than double the time and number of sessions when compared to the care and aftercare related to a conventional denture. This could be interpreted as a negative aspect, but many studies have

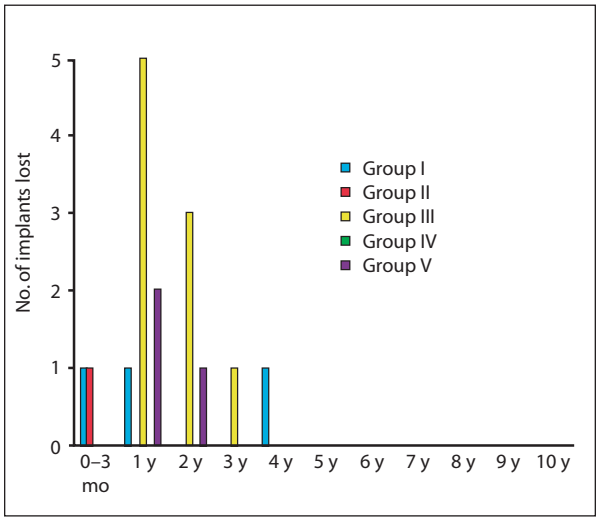

Fig 2 Loss of implants as a function of time after placement of the implants. No loss of implants was observed in patients from groups 2 and 4 who switched to an implant-retained mandibular overdenture, or for the replaced implants in groups 1, 3, and 5.

shown higher satisfaction scores for patients with implant-retained overdentures compared to patients with conventional dentures. Patients seemed very satisfied with their implant-retained overdentures and remained satisfied throughout the study, while patients treated with conventional dentures became more dissatisfied with time.[2,24–26] This observation is also in line with the Mc Gill consensus statement on overdentures, suggesting that restoration of the edentulous mandible with conventional dentures is no longer the most appropriate prosthodontic treatment.[27] According to the statement, an implant-retained overdenture has evolved to the first choice of treatment for the edentulous mandible. Further, when compared to a fixed partial denture, a mandibular overdenture is a less expensive treatment.[28] When compared to a mandibular overdenture with ball-spring attachment, a bar-retained overdenture as used in this study requires fewer repairs.[29] However, the higher need for prosthetic

maintenance for implant-supported designs should be discussed with patients prior to treatment.[14]

It is concluded that patients treated with an implant-retained mandibular overdenture need more care and aftercare than patients treated with a conventional denture, even when some patients in group 5 switched to an implant-retained overdenture. With regard to aftercare, improvements in design and surface treatment of implants, the use of Dolder bars, and the use of porcelain molars are believed to result in considerably less aftercare. However, despite the greater amount of care and aftercare and its related costs, the significantly higher patient satisfaction recorded should also be factored into any decision between implant-retained and conventional dentures; hence the current opinion that implant-retained overdentures are the best treatment option for patients with mandibular denture complaints.

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