Implant-Retained Maxillary Overdentures on Milled Bar Suprastructures: A 10-Year Follow-up of Surgical and Prosthetic Care and Aftercare

Anita Visser, DDS[a]/Gerry M. Raghoebar, DDS, MD, PhD[b]/Henny J. A. Meijer, DDS, PhD[b,c]/Arjan Vissink, DDS, MD, PhD[b]

Purpose: The aim of this study was to evaluate surgical and prosthetic care and aftercare of maxillary overdentures supported by six endosseous implants and a milled bar mesostructure with Ceka attachments. ***Materials and Methods:*** Thirty-nine consecutive patients with an edentulous maxilla who reported problems wearing a conventional maxillary denture were treated with an overdenture supported by six endosseous implants and a milled bar mesostructure (solid bar with position Ceka attachments). Prosthetic and surgical care and aftercare were scored from the first visit until 10 years after the augmentation of the maxilla. Patient satisfaction was assessed at the end of follow-up. ***Results:*** On the basis of problems patients experienced with wearing their conventional dentures, three groups of patients were distinguished: patients with lack of retention of their conventional maxillary denture related to anatomic problems (n = 24), patients with gagging problems (n = 9), and patients not tolerating a conventional maxillary denture due to subjective problems not related to an anatomic substratum (n = 6). The need for care and aftercare was comparable between the three groups. The overall 10-year implant survival rate was 86.1%. Loss of implants occurred mostly during the first year after placement. Surgical aftercare predominately consisted of care related to the removal and replacement of implants (ie, reaugmentation, replacement of implants, and abutment connection). Prosthetic aftercare consisted mainly of routine inspections, oral hygiene care, and activation or replacement of Ceka attachments. Finally, all patients functioned well with their overdentures and remained satisfied throughout the study. ***Conclusion:*** Irrespective of the mentioned underlying reasons for not functioning with a conventional maxillary denture, an implant-retained maxillary overdenture, opposed by either an implant-retained mandibular overdenture or natural dentition, was shown to be an effective, predictable, and reliable treatment option that did not need much aftercare other than adjustments of the Ceka attachments. *Int J Prosthodont 2009;22:181–192*

[a]*Assistant Professor, Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands.*
[b]*Professor, Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands.*
[c]*Professor, Department of Oral Function and Prosthetic Dentistry, Dental School, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands.*

Correspondence to: *Dr Anita Visser, Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics, University Medical Center Groningen, PO Box 30001, 9700 RB Groningen, The Netherlands. Fax: +31-50-3611136. Email: a.visser@kchir.umcg.nl*

Denture function in edentulous patients is often inadequate.[1] Atrophy of the alveolar ridges frequently causes great difficulty in wearing conventional dentures due to a lack of retention and instability of the denture. Together with a poor load-bearing capacity of the tissues, this can lead to oral pain, oral discomfort, and poor oral function.[2]

Since their introduction in the early 1970s, fixed partial dentures (FPDs) and implant-retained overdentures have developed into reliable treatment options in cases of edentulism both in the mandible and maxilla.[3,4] Meanwhile, both FPDs and implant-retained

Table 1 Overview of Studies Reporting on Implant Survival in the Maxilla Published During the Last Decade*

Author	Year of publication	No. of implants	Length of follow-up	Implant survival rate (%)	Type of suprastructure
Johns et al[43]	1992	117	1 y	81	OD
Jemt et al[29]	1992	430	1 y	84	OD
Hutton et al[40]	1995	117	3 y	75.2	OD
Brånemark et al[25]	1995	882	10 y	78.3–80.3†	FPD
Chan et al[2]	1996	105	5 y	84.0	OD
Jemt et al[42]	1996	117	5 y	72.4–77.9†	OD
Ekfeldt et al[49]	1997	195	34 mo	79.3–84.3†	OD
Watson et al[26]	1997	117	60 mo	72.4	OD
Toljanic et al[50]	1997	162	13 mo	100	OD
Watzek et al[51]	1998	155	70 mo	95.4	FPD and OD
Blomqvisk et al[52]	1998	314	9–48 mo	80.9	FPD and OD
Kaptein et al[39]	1998	470	70 mo	82.2	FPD and OD
Balshi et al[53]	1999	1,817	4 y	88.2	FPD
Smedberg et al[54]	1999	154	35–82 mo	84–85†	OD
Keller et al[55]	1999	248	81 mo	87	OD
Rodriquez et al[10]	2000	> 2,900	3 y	94.6	OD
Raghoebar et al[17]	2001	392	58 mo	91.8	FPD and OD
Kiener et al[14]	2001	173	38 mo	95.5	OD
Zitzmann and Marinello[28]	2000	155	33 mo	94.4–97.6	FPD and OD
Fortin et al[16]	2002	245	5 y	97.0	OD
Mericske-Stern et al[56]	2002	173	5 y	94.2	OD
Bergkvist et al[24]	2004	146	5 y	96.6	FPD
Becktor et al[57]	2004	437	5–6 y	75.1 (grafted)	FPD and OD
		683	5–6 y	84.0 (nongrafted)	FPD and OD
Fischer et al[58]	2004	142	1 y	100	FPD
Balshi et al[44]	2005	840	3 y	98.3	FPD
Widbom et al[31]	2005	145	5.7 y	77 and 46	FPD and OD

FPD = Fixed partial denture; OD = overdenture
*Only studies analyzing at least 100 implants are included in this table.
†Survival rates reported were dependent on the number of implants placed in the edentulous maxilla (various designs for support of the fixed partial denture or overdenture were used in those studies).

overdenture designs have been tested in clinical studies, resulting in more favorable outcomes for implant-retained maxillary overdentures when it comes to speech,[5–7] function,[8] esthetics, taste,[5] safety, efficacy, and effectiveness.[9,10] Moreover, while FPDs are only appropriate for patients with minimal resorption of alveolar bone and an optimal maxillomandibular relationship, implant-retained maxillary overdentures are also applicable in patients with progressed resorption of the maxilla and less favorable maxillomandibular relationships.[11] Finally, several studies showed that the implant-retained maxillary overdentures on milled bar suprastructures with Ceka attachments are a reliable treatment option.[12–16]

Since the use of endosseous implants in the edentulous maxilla is often limited by an insufficient quantity of available bone,[17] the majority of studies concerned with the rehabilitation of the edentulous maxilla using implants have focused on preimplant surgical procedures[18,19] and thus have studied parameters such as implant survival rates (Table 1), conditions of the peri-implant tissues, and bone loss adjacent to the implants.[2,17,20] Other authors focused on treatment concepts and reported that an implant-retained maxillary overdenture on a bar suprastructure supported by six to eight implants was a proper concept.[11,21–23] Moreover, studies that assessed prosthetic aftercare focused mainly on FPDs, and the aftercare provided was described in general terms.[24–28] The few studies that mentioned aspects of prosthetic aftercare provided to implant-retained maxillary overdentures reported complications with the attachment components,[14,16,29–31] fracture of the mesobar structure,[12] fractures of the Ceka attachments, fractures of the acrylic resin or teeth,[14,29] and adjustments to the overdenture.[32] The aforementioned overdenture studies simply described some of the aftercare they encountered in their patient cohorts and reported their experiences in patients treated with a variety of implant-based treatment concepts. Therefore, the aim of this 10-year follow-up study was to evaluate all surgical and prosthetic care and aftercare related to implant-retained maxillary overdentures supported by six endosseous implants and a milled bar mesostructure. In addition, patient satisfaction with this treatment design was measured.

Table 2 Group Characteristics

	Number of patients	Mean age (range) (y)	Gender (female/male)	Total number of implants (secondary)
Group I: anatomic problems	24	62 (26–72)	14/10	144 (14)
Group II: gagging problems	9	57 (31–62)	5/4	54 (0)
Group III: other problems	6	55 (44–67)	2/4	36 (4)
Total	39	59 (26–72)	21/18	234 (18) = 252

Materials and Methods

Patients

Patients who were referred by their dental clinician or general medical practitioner to the Department of Oral and Maxillofacial Surgery and Maxillofacial Prosthodontics of the University Medical Center Groningen between 1989 and 1997 because of persistent problems with wearing a conventional maxillary denture were selected for this study. To be included in this study, patients must have:

- Experienced problems with wearing a conventional maxillary denture in a resorbed maxilla
- Had an indication for placement of implants in the maxilla
- Received an implant-retained maxillary overdenture on six Brånemark implants and a milled bar with Ceka attachments
- Been treated at the prosthetic unit of this particular department
- Completed a 10-year follow-up

Patients with a history of radiotherapy in the head and neck region, patients with an immunocompromised status (eg, Sjögren's syndrome, erosive lichen planus), patients who had received their implant-retained maxillary overdenture from a prosthetic facility other than this, and patients who had had a follow-up of less than 10 years were excluded.

In total, 39 patients complied with the inclusion criteria (21 women and 18 men, mean age: 59 ± 9 years, range: 26 to 72 years) (Table 2). Seventeen patients had an implant-retained mandibular overdenture on four implants, 15 had their natural dentition in the mandible, and four wore an implant-retained mandibular overdenture on two implants. Three out of the 39 patients had a conventional mandibular denture. In the medical files of these patients, all items related to surgical and prosthetic care and aftercare concerning this implant treatment in the maxilla had been scored with great detail. After placement of the implant-retained maxillary overdenture, all patients were recalled once a year unless they experienced complaints or when an aftercare problem was observed during a recall visit.

Surgical and Prosthetic Procedures

Treatment of all patients was performed within in the same department by experienced oral and maxillofacial surgeons and prosthodontists. In all cases the bone volume was insufficient for reliable implant placement, thus requiring augmentation and elevation of the maxillary sinus floor. Three months after sinus augmentation, six dental implants (smooth turned surface, diameter: 3.75 mm, length: 10 to 15 mm; Brånemark implant system, Nobel Biocare) were placed on each side using general anesthesia, three implants in each premolar/molar region. Abutment connection was performed 6 months after implant placement.

The surgical protocol (augmentation and elevation of the maxillary sinus floor, implant insertion, abutment connection) has been described in detail by Raghoebar et al.[17,33] In all cases, surgical templates were used to assure the direction and position of the implants to facilitate prosthetic rehabilitation. During the healing period of 3 months for the augmentation and 6 months for the implants, the patients' conventional maxillary dentures were adjusted, if possible, and supplied with a softliner. Two weeks after the second stage of surgery, standard prosthetic treatment was carried out, ie, the fabrication of an implant-retained maxillary overdenture with porcelain elements (Vivopearl PE, Ivoclar Vivadent) on a milled bar mesostructure with Ceka position attachments (Revax Ceka attachment NV) (Figs 1 to 3), as described in detail by Lothigius et al.[22] In these patients, the mesostructure was fabricated on implants placed in the premolar/molar region because of a lack of space for the milled bar mesostructure in the anterior region. A six-implant concept was chosen since it has been shown that excellent results can be achieved with six implants in the maxillary arch.[34,35]

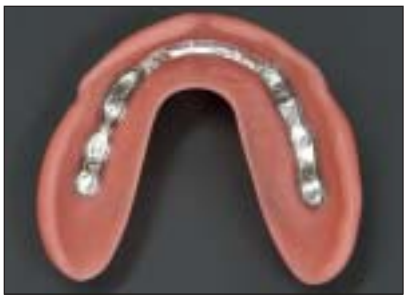


Fig 1 *(left)* Milled bar suprastructure with Ceka attachments.

Fig 2 *(right)* Implant-retained maxillary overdenture with Ceka attachments.

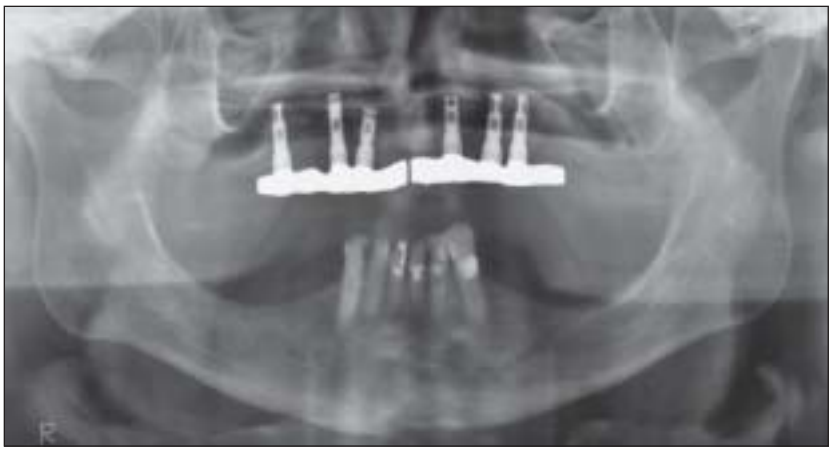


Fig 3 Rotational panoramic radiograph showing a milled bar suprastructure on six maxillary implants.

Clinical Analysis

The clinical analysis included a number of parameters. First, the patient's reasons for not complying with wearing a conventional maxillary denture were recorded. Next, from the moment augmentation was performed until 10 years after augmentation, every visit to the clinic and all surgical or prosthetic therapeutic interventions were scored using a standardized score list. All scores were done on a per day basis, so if a patient had to come more than once on the same day (eg, clip repair) it was scored as one treatment session. The average treatment time in minutes allocated to a particular variable (Tables 3 to 6) was based on the average treatment time for that variable as indicated by experienced prosthodontists and oral and maxillofacial surgeons. Only chair time was counted. The received surgical and prosthetic care and aftercare was scored for five well-defined periods, as previously defined by Visser et al.[36]

Pretreatment Period (diagnostic period). Time from the agreement between the clinicians and patients to fabricate an implant-retained maxillary overdenture to the start of surgical treatment. The variables scored included consultations for treatment explanation and planning (including fabrication of the diagnostic template if needed).

Surgical Period. Time from the start of surgical treatment (augmentation) until 2 months after the implant-retained maxillary overdenture was placed. The variables scored included: sessions for surgical treatment as augmentation of the maxilla with bone from the anterior iliac crest, sessions for placing implants, sessions for abutment connection, sessions for postoperative care, fabrication of the templates, and removal of mobile implants during current treatment.

Prosthetic Period. Time from the start of prosthetic treatment until 2 months after the implant-retained maxillary overdenture was placed. The variables scored included: applying a softliner and adjusting conventional dentures after surgery, fabrication of an implant-retained maxillary overdenture, relief of sore spots, relining of the maxillary overdenture, activating Ceka attachments, grinding occlusion, oral hygiene support, adjustment of occlusion level, and lengthening the denture base.

Surgical Aftercare. Time from 2 months after the implant-retained maxillary overdenture was placed until the end of the 10-year follow-up. The variables scored included: removal of implants; reaugmentation of the maxilla; replacement of implants, palatal grafts, and local vestibuloplasty; placing abutments; gingivectomy/thinning of mucosa/removal of hyperplasia; flap treatment (treatment of triangle-shaped

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

	Group I n = 24	Group II n = 9	Group III n = 6	Overall
Augmentation of maxilla with anterior iliac crest bone (120 min)	1.00 ± 0.00	1.11 ± 0.33	1.17 ± 0.41	1.05 ± 0.22
Session for placing implants (60 min)	1.00 ± 0.18	1.00 ± 0.00	1.17 ± 0.41	1.03 ± 0.16
Session for abutment operation (30 min)	1.00 ± 0.18	1.00 ± 0.00	1.17 ± 0.41	1.03 ± 0.16
Session for postoperative care (15 min)	13.88 ± 4.59	12.00 ± 4.27	11.67 ± 7.06	13.10 ± 5.02
Sessions for fabrication of templates (15 min)	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
Removal of nonosseointegrated implants during current treatment (10 min)	0.17 ± 0.48	0.09 ± 0.30	0.83 ± 2.04	0.24 ± 0.86
Average time needed per patient	424 min	419 min	444 min	433 min

*Treatment time is exclusive of hospitalization: on average 7 days.

Table 4 Surgical Aftercare Period: Mean No. of Interventions (± SD) and Overall Treatment Time Per Patient (Average Treatment Time)

	Group I n = 24	Group II n = 9	Group III* n = 6	Overall
Removal of implants (10 min)	0.21 ± 0.51	0.44 ± 1.01	0.00 ± 0.00	0.23 ± 0.63
Reaugmentation of the maxilla with crista bone (120 min)	0.00 ± 0.00	0.11 ± 033	0.00 ± 0.00	0.03 ± 0.16
Session for replacement of implants (45 min)	0.08 ± 0.28	0.22 ± 0.44	0.00 ± 0.00	0.10 ± 0.31
Palatal grafts/local vestibuloplasty (45 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Session for placing abutments (25 min)	0.21 ± 0.51	0.22 ± 0.44	0.00 ± 0.00	0.18 ± 0.45
Gingivectomy/thinning mucosa/removal of hyperplasia (15 min)	0.13 ± 0.34	0.00 ± 0.00	0.00 ± 0.00	0.08 ± 0.27
Flap treatment (30 min)	0.00 ± 0.00	0.11 ± 033	0.00 ± 0.00	0.03 ± 0.16
Consult without treatment (15 min)	0.17 ± 0.56	0.44 ± 1.01	0.00 ± 0.00	0.21 ± 0.66
Consult with minor treatment (20 min)	0.04 ± 0.20	0.33 ± 1.00	0.00 ± 0.00	0.10 ± 0.50
Session for postoperative care (15 min)	0.88 ± 1.73	2.78 ± 5.29	0.00 ± 0.00	1.18 ± 2.93
Average time needed per patient	29 min	91 min	0 min	40 min

*All loss of implants occurred during the care period (see Table 3).

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

	Group I n = 24	Group II n = 9	Group III n = 6	Overall
Removal of implants (10 min)	0.21 ± 0.51	0.44 ± 1.01	0.00 ± 0.00	0.23 ± 0.63
Applying softliner and adjusting conventional dentures after surgery (20 min)	1.75 ± 1.85	0.44 ± 1.01	3.00 ± 4.98	1.64 ± 2.49
Fabrication of implant-retained maxillary overdenture (165 min)	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00	1.00 ± 0.00
Relieving denture sore spots (10 min)	0.54 ± 0.66	0.56 ± 1.01	0.33 ± 0.82	0.49 ± 0.76
Relining implant-retained maxillary overdenture (25 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Activating Ceka attachments (5 min)	0.29 ± 0.55	0.00 ± 0.00	0.17 ± 0.41	0.21 ± 0.47
Grinding of occlusion (10 min)	0.46 ± 0.78	0.22 ± 0.44	0.50 ± 0.84	0.44 ± 0.72
Oral hygiene support (15 min)	2.79 ± 1.59	2.56 ± 1.67	2.33 ± 1.51	2.67 ± 1.56
Adjustment of occlusion level (25 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Lengthening denture base rim (20 min)	0.29 ± 0.46	0.22 ± 0.67	0.17 ± 0.41	0.26 ± 0.50
Average time needed per patient	259 min	224 min	272 min	253 min

bone deformities next to the implants, with or without placement of a membrane); consultation without treatment; consultation with minor treatment (correction of small hyperplasia around abutment, removal of sequester); and postoperative care (removal of sutures, changing abutments, checking wound healing).

Prosthetic Aftercare. Time from 2 months after the implant-retained maxillary overdenture was placed until the end of the 10-year follow-up. The variables scored included: routine and prevention inspections, oral hygiene instructions, removal of calculus, repair of the denture teeth, repair of the denture base, fabrication of a new milled bar, repair of the Ceka attachments, fabrication of a new maxillary overdenture, adjustment of occlusion level, softliner application in the maxillary overdenture, relining the maxillary overdenture, repair of the milled bar, grinding of occlusion, consultation without treatment (complaints about discomfort, fear

Table 6 Prosthetic Aftercare Period: Mean No. of Interventions (± SD) and Overall Treatment Time Per Patient (Average Treatment Time)*

	Group I n = 24	Group II n = 9	Group III n = 6	Overall
Routine/prevention and after treatment inspection (15 min)	10.71 ± 5.30	8.22 ± 3.35	8.17 ± 5.56	9.74 ± 4.99
Oral hygiene instructions (15 min)	10.29 ± 6.88	7.11 ± 5.11	7.00 ± 3.85	9.05 ± 6.08
Removal of calculus (10 min)	3.25 ± 3.53	1.67 ± 1.41	1.67 ± 3.14	2.64 ± 3.14
Repair denture teeth (15 min)	0.38 ± 0.71	1.11 ± 1.76	0.33 ± 0.52	0.54 ± 1.05
Repair denture base (15 min)	0.08 ± 0.28	0.78 ± 1.99	0.00 ± 000	0.23 ± 0.99
Fabrication of new milled bar (105 min)	0.13 ± 0.45	0.33 ± 0.50	0.17 ± 0.41	0.18 ± 0.45
Replacing Ceka attachment (20 min)	0.63 ± 1.31	0.11 ± 0.33	0.67 ± 1.63	0.51 ± 1.21
Fabrication of new denture (135 min)	0.17 ± 0.38	0.33 ± 0.50	0.50 ± 0.84	0.26 ± 0.50
Adjustment of occlusion level (30 min)	0.13 ± 0.45	0.11 ± 0.33	0.33 ± 0.82	0.15 ± 0.49
Softliner application maxillary overdenture (15 min)	0.25 ± 0.61	0.33 ± 0.50	0.17 ± 0.41	0.26 ± 0.55
Relining maxillary overdenture (25 min)	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Repair of milled bar (40 min)	0.04 ± 0.20	0.11 ± 0.33	0.00 ± 0.00	0.05 ± 0.22
Grinding of occlusion (10 min)	0.38 ± 0.58	0.22 ± 0.44	1.17 ± 1.94	0.46 ± 0.91
Consult without treatment (15 min)	0.42 ± 0.78	0.11 ± 0.33	0.17 ± 0.41	0.31 ± 0.66
Activating Ceka attachments (10 min)	1.25 ± 1.67	0.22 ± 0.44	0.67 ± 1.21	0.92 ± 1.46
Consults with minor treatment (15 min)	1.83 ± 1.71	1.11 ± 1.36	2.67 ± 3.93	1.79 ± 2.10
Relieve sore spots (10 min)	0.46 ± 0.93	0.44 ± 0.73	0.33 ± 0.82	0.44 ± 0.85
Replacement of screws and/or abutments (15 min)	0.29 ± 1.00	0.11 ± 0.33	0.17 ± 0.41	0.18 ± 0.80
Lengthening denture base rim (25 min)	0.04 ± 0.20	0.00 ± 0.00	0.00 ± 0.00	0.03 ± 0.16
Average time needed per patient	467 min	397 min	424 min	443 min

*Radiographs taken for routine inspections or consultations because of pain complaints were not included in this table.

of oral cancer, taste problems), activating Ceka attachments, consultation with minor treatment (sharp edges on teeth), relieving sore spots, replacement of screws and/or abutments, and lengthening the denture base rim.

In all cases the prosthodontists performed the routine inspections and were responsible for checking prosthetic problems with the implant-retained maxillary overdenture as well as surgical problems related to the implants. If there were severe problems on the surgical field, the prosthodontist referred the patient to the oral surgeon for further treatment.

Patient Satisfaction

To measure the overall patient satisfaction, the patients were asked to complete a questionnaire at the end of the 10-year follow-up. Patients had to give their personal overall satisfaction score regarding their implant-retained maxillary overdenture and the treatment they had received on a visual analog scale (VAS). The VAS ranged in 10 equidistant steps from a negative to a positive attitude, where a high numeric value represented a positive opinion.[7,37] A VAS was used to measure patient satisfaction since using a VAS has been shown to be a valid and reliable instrument in retrospective studies.[8,31,38] In addition, four statements were presented to the patients according to the approach used by Smedberg et al[15] and Kaptein et al[39]:

1. Are you more satisfied with your implant-retained maxillary overdenture than you were with your previous conventional maxillary denture? Yes/No/No opinion
2. When you consider the whole treatment was it worthwhile for you to undergo the treatment? Yes/No/No opinion
3. If you would have known exactly what the treatment consisted of at the start of your implant treatment, would you have chosen again to undergo this treatment? Yes/No/No opinion
4. Would you advise your friends and relatives to undergo the treatment if they had comparable problems as you had before the treatment? Yes/No/No opinion

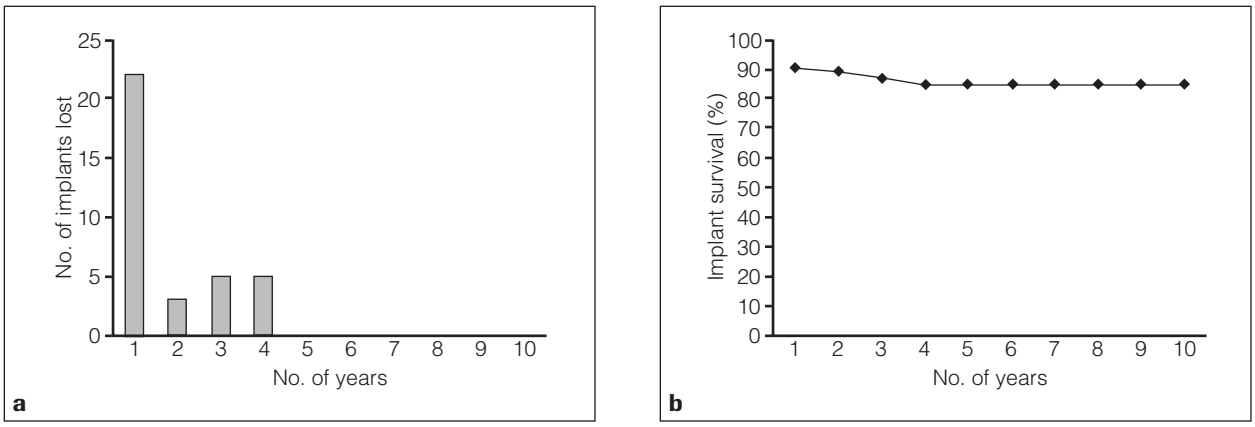
Statistical Analysis

The data were analyzed using *t* tests for the continuous data and Mann-Whitney *U* tests for the ordinal data. In all tests a significance level of .05 was chosen.

Results

Patients

Based on careful examination of patients' reasons for not tolerating a conventional maxillary denture, three groups of patients could be distinguished:



Figs 4a and 4b Loss of implants as a function of time after placement.

- Group I: patients with a lack of retention of their conventional maxillary denture related to anatomic problems, such as severe resorption of the maxilla and a high attachment of the mucosa (n = 24)
- Group II: patients with gagging problems (n = 9)
- Group III: patients with subjective problems of wearing their conventional maxillary denture, eg, related to burning mouth syndrome, subjective pain complaints, and adaptation problems not related to an anatomic substratum (n = 6)

The patients' characteristics of the various groups are shown in Table 2. In all cases, the various analyses were performed for the overall patient cohort and the three groups separately. Moreover, 20% of the patients were suffering from psychological distress (psychological treatment for depression [n = 2], overstrained due to retention problems of the conventional maxillary denture [n = 1], nervositas [n = 1]) or psychiatric distress (schizophrenia [n = 1], severe depression [n = 1], problems treated by a psychiatrist not mentioned in detail by the patient [n = 2]). When looking into detail, psychological/psychiatric distress was common among patients in group III (three of the six patients, 50%; $P <$ .05), while such distress was significantly less prominent among the patients of groups I (four of 24, 17%) and II (one of nine, 11%).

Pretreatment Period

On average, patients needed 3.44 ± 1.37 treatment sessions (median: 3.4) for consultation and technical procedures (diagnostic and surgical templates) before augmentation was performed. These sessions were for consultations (first visit, surgical review, and prosthetic review) and technical preparations (fabrication of a template).

Surgical Care and Aftercare Period

Concerning surgical care, there were no significant differences in the various procedures performed between the three groups (see Tables 3 and 4). However, with regard to surgical aftercare, patients in group III needed significantly less aftercare ($P <$ .01), which was mainly due to no one losing an implant in this group of patients. In two cases it was necessary to perform reaugmentations before implant placement could take place at the planed position due to an extensive loss of bone in the augmentation area (one patient from group I [two reaugmentations] and one patient from group II [one reaugmentation]).

Two hundred thirty-four implants were initially placed (six implants per patient). Due to implant loss, 18 additional implants were placed. In total, 252 implants were placed in this group of patients. From these, 35 implants were lost in 15 patients during the 10-year follow-up, resulting in a survival rate of 86.1%. Figure 4 shows that the majority of implants had been lost during the first year after placement. The implant survival rate was strongly dependent upon three patients who lost a relatively high number of implants (seven, six, and four implants, respectively; in total, 17 of the 35 total lost implants). Thirteen of the 18 additionally placed implants were inserted in these three patients. In most other patients, a prosthetic construction was made on the remaining implants.

The surgical aftercare needed for all patients was usually rather minor and mostly consisted of treatment for implant removal and replacement of implants. Consultations with or without minor treatment (eg, assessment of peri-implant conditions or persistent pain) were rarely needed.

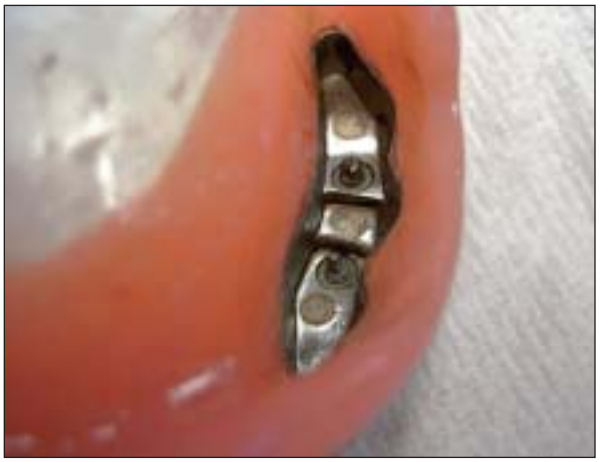


Fig 5 Fractured Ceka attachments.

Table 7 Mean Overall Treatment Time and No. of Sessions for All Periods on Average Per Patient

	Group I anatomic	Group II gagging reflex	Group III other	Overall
Surgical care period	424 min	419 min	444 min	433 min
Surgical aftercare period	29 min	91 min	0 min	40 min
Prosthetic care	259 min	224 min	272 min	253 min
Prosthetic aftercare	467 min	397 min	424 min	443 min
Total	1,179 min	1,131 min	1,140 min	1,168 min
	57.5 ± 12.4 sessions	57.2 ± 14.0 sessions	55.5 ± 15.1 sessions	57.3 ± 12.82 sessions

In one patient, a surgical complication developed during the care period, ie, the development of a seroma in the iliac crest area that needed drainage. In two other patients, including the patient in whom seven implants were lost, reaugmentation was needed due to extensive bone loss.

Prosthetic Care and Aftercare

Prosthetic care was related to the fabrication of an implant-retained maxillary overdenture. Patients from group II (gagging problems) received significantly less applications of a softliner to adjust their conventional dentures after augmentation and implant treatment since most of the patients in this group could not wear a conventional maxillary denture (see Table 5). Prosthetic aftercare predominately consisted of routine inspections and oral hygiene care (see Table 6). More specific prosthetic corrections that were needed during the aftercare period mostly consisted of consults with minor treatment, activation of Ceka attachments, and repair of loose or broken Ceka attachments (Fig 5). In addition, 23% of patients needed new implant-retained maxillary overdentures, over half of these cases (five out of nine patients) because of implant loss and reimplantations. Other reasons for making new overdentures were abrasion, esthetic problems and subjective tensions, and pain sensations. Relining of an implant-retained maxillary overdenture was not needed during the 10-year follow-up and relief of sore spots was hardly needed. In one patient, both the patient and prosthodontist were unable to remove a new overdenture from the suprastructure. This overdenture had to be removed in parts using a dental drill.

Overall Treatment Time

On average the mean number of treatment sessions needed per patient was 57.3 ± 12.8 sessions (median: 57 sessions), of which the most time consuming, with regard to number of sessions and time involved per session, were the surgical and prosthetic care periods, both provided in the first year of this study. The treatment time needed during the remaining follow-up can be considered minor and mostly consisted of routine recall visits for prosthetic check-ups and oral hygiene care. No significant differences in number of sessions and overall treatment time were observed between the three groups (Table 7).

Patient Satisfaction

All patients functioned well with their implant-retained maxillary overdentures. The mean 10-year score for the overall satisfaction with wearing implant-retained maxillary overdentures was 8.9 ± 1.1 (median: 9, range: 7 to 10). The mean satisfaction scores for group II tended to be slightly higher than the scores for the other two groups (9.3 ± 1.0, median: 9, range: 9 to 10). The patients in group II mentioned that they were not able to wear a conventional maxillary denture due to gagging problems. They functioned well with their implant-retained maxillary overdentures. All patients who mentioned being more satisfied with an implant-retained maxillary overdenture than their previous conventional maxillary denture were willing to undergo the surgical and prosthetic treatment again if needed, and would suggest an implant-retained maxillary overdenture to friends and relatives with comparable problems of wearing a conventional maxillary denture.

Discussion

Implant-retained maxillary overdentures on milled bar suprastructures with Ceka attachments were shown to be a time-consuming but reliable treatment option for both the prosthodontist and the patient. Remarkably, the overall care and aftercare needed to fabricate and maintain an implant-retained maxillary overdenture appeared to be independent of the patients' reasons for not wearing a conventional maxillary denture. Moreover, even after a follow-up of 10 years, patient satisfaction was still high. Finally, the surgical and prosthetic aftercare needed for maintenance was minor. Approximately two thirds of the overall aftercare treatment time was dedicated to routine inspections and oral hygiene care.

Before the start of this study, it was assumed that the time for care and aftercare needed by patients might be related to the patients' reasons for not wearing conventional maxillary dentures. However, the overall treatment time was shown to be comparable between the three groups. Nevertheless, there are some typical differences between them that can be easily explained. For example, adjustments of the conventional maxillary denture were needed significantly less in patients with gagging problems (group II) compared to the patients from groups I and III, which is probably due to the phenomenon that most patients with gagging problems did not wear their conventional dentures.

Regarding surgical care and aftercare, part of this was related to the replacement of lost implants (survival rate: 86.1%). The moderate implant survival rate observed in this study might be related to an overrepresentation of extremely resorbed maxillae and the use of smooth turned implants. As is apparent from Table 1, more favorable implant survival rates in edentulous maxillae have predominantly been reported for FPDs, which are only applied in less resorbed maxillae. This is in agreement with patient group III, as most patients in this group had a moderate resorbed maxilla and no loss of implants was observed. Moreover, the higher implant loss in groups I and II, groups in which most patients had a severely resorbed maxilla, is in agreement with other studies.[20,40–43] These studies indicated that poor jaw bone quality and small bone volume at the time of implant surgery may result in more implant and denture failure than when favorable jaw bone characteristics are present. In the majority of patients, resorption was severe and the intermaxillary characteristics were unfavorable for FPDs. As mentioned, another explanation for the rather low implant survival is the type of implants that were used. The implants were placed between 1990 and 1996, a period in which different surface coatings were used on implants than today. The use of smooth turned Brånemark implants might have influenced the implant survival rate unfavorably. Nowadays, Brånemark implants are provided with a Ti-Unite surface, where in earlier days they were smooth turned or machined. Balshi et al[44] reported significantly higher 3- to 4-year implant survival rates for Ti-Unite surfaces (98.6%) versus machined implant surfaces in the edentulous maxilla (92.1%). In more recent implant studies from our clinic using implants with the Ti-Unite surface, Raghoebar et al[45] reported implant survival rates comparable to the rates reported by Balshi et al.[44] Moreover, loss of implants occurred mostly during the first year after placement, which is in agreement with the observations of Balshi et al[44] and Jemt[32] for the edentulous maxilla and Visser et al[36] and Adell et al[46] for the edentulous mandible. Furthermore, one should keep in mind that in this study, as is often the case in other studies, the far majority of implants were lost in only a few number of patients. Finally, since implant failure was shown to be the most important reason for making a second implant-retained maxillary overdenture in this study, a higher implant survival rate will directly influence the outcome of prosthetic aftercare (less effort on patients, less costs).

Regarding prosthetic care and aftercare, the design of an implant-retained maxillary overdenture on six implants worked well. This is in agreement with the statement of Brånemark et al[25] that placement of more than six implants in an edentulous maxilla to support an overdenture should be seriously questioned. When looking into detail at the aftercare provided, relief of denture sore spots and relining of the overdenture was hardly needed, while in about half of the patients there was a need to reactivate Ceka attachments and in about one fourth of patients Ceka attachments had

to be replaced. The implant design used in this study (three implants in the left and right posterior maxilla) might explain the lesser need for relief of denture sore spots and relining of maxillary overdentures when compared to the studies of Kiener et al,[14] Smedberg et al,[15] and Jemt et al[29] since in our study all implant-retained maxillary overdentures were implant-worn and thus avoided pressure on the denture-bearing mucosa. The greater need for prosthetic aftercare regarding reactivating and replacement of Ceka attachments is in agreement with complications reported in a study by Naert et al.[30] Widbom et al,[31] who used a rigid cast alloy bar designed with ball attachments retaining a maxillary overdenture in their study, also observed a high number of technical complications related to that attachment system. Finally, Sadowsky[47] mentioned that regardless of the anchorage system, the predominant complication in maxillary overdenture therapy involves a change in the retention system resulting from loosening or fracture.

Usually, replacement of a Ceka attachment is an easy, chairside procedure. However, when the Ceka attachment head is fractured, replacement can become a major effort because of a lack of grip to unscrew the Ceka attachment from the metal overstructure in the overdentures. In addition, fabrication of a milled bar with Ceka attachments is more of an effort to a technician than fabrication of a solid bar with clip attachments. Therefore, since 2005 we have changed our prosthetic design from a milled gold alloy bar with Ceka attachments into a thick egg-shaped milled titanium solid Dolder bar construction (the so-called Steggelenk bar, milled by ISUS, E. S.Tooling) with matching clip attachments (matrix Macro, Cendres-Métaux). To prevent frequent clip fracture, as also reported by Jemt[48] and Visser et al,[36] we currently laser the clip attachments on a metal reinforcement that is incorporated in the acrylic base of the overdenture. Now, we feel that the need for reactivation and replacements of the clips has been considerably reduced.

In the current study, calculations were only made for dental chair time from the moment that the surgical treatment was started. Other time investments and costs, eg, administration, treatment planning, hospitalization, (dental) technical labor, and making radiographs, were not included in this study. This was done to present the need for care and aftercare of an implant-retained maxillary overdenture as clear-cut as possible.

Finally, the patients included in the current study reported very high satisfaction scores for their implant-retained maxillary overdentures. It must be noted, however, that in the current study patients' satisfaction was not assessed in a prospective study design measuring satisfaction before treatment, one month after placement of the overdenture, and at standardized intervals during follow-up, but rather only once at the 10-year follow-up. Notwithstanding these limitations, the high patient satisfaction scores reported in this study are in line with the studies of Kronström et al,[7] Smedberg et al,[15] Naert et al,[30] and Kaptein et al.[39]

Conclusion

From this study it can be concluded that irrespective of the patients' reasons for not functioning with a conventional maxillary denture, an implant-retained maxillary overdenture, opposed by either an implant-retained mandibular overdenture or natural dentition, was shown to be an effective, predictable, and reliable treatment option not requiring much aftercare other than adjustments of the Ceka attachments.

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Literature Abstract

Distribution of biofilm on internal and external surfaces of upper complete dentures: The effect of hygiene instruction

This study evaluates biofilm distribution over the internal and external surfaces of complete maxillary dentures, as well as the efficacy of oral hygiene instructions using disclosing solution. The study was conducted in two stages using 29 complete denture wearers. Biofilm from the previous deposits was disclosed with a 1.0% neutral red solution and mechanically removed using a hand brush and denture brush with liquid soap. Following biofilm removal, the dentures were returned to the subjects. During the first stage, subjects were shown how to clean their dentures. The protocol consisted of using a specific brush and toothpaste. Biofilm distribution was recorded at four weekly examinations, disclosed with the solution, and the dentures were cleaned and returned to the participants. The second stage involved similar hygiene instructions, in addition to the use of a disclosing agent. The subjects were also examined four times to record biofilm accumulation. The internal surface was divided into 14 areas and the external surface was divided into eight. Each area was scored from 0 to 4 and a hygiene index was calculated (sum of individual score divided by the number of evaluated areas on surface). Statistical analysis involved the Friedman test, followed by the Dunn multiple comparison test to evaluate the hygiene index of the internal and external surfaces. As for the scores of biofilm for individual areas, a rank test was employed for assessment of the interaction between "areas" and "stages." The mean scores for each area were compared using ANOVA for repeated measures. The Student-Newman-Keuls test was used for post hoc comparisons. The results indicated that internal and external surfaces had a similar amount of biofilm concentrated over the posterior teeth, rugae area, and the internal vestibular incline of the distobuccal flange. The overall amounts were reduced following denture hygiene information and the use of disclosing solution resulted in a further reduction. The author concludes that oral health instruction was effective in reducing the biofilm, especially when associated with the use of disclosing agent. This study supports the importance of oral hygiene instructions to denture wearers and may assist policy makers in designing home care programs for their long term residents wearing dentures.

Paranhos Hde F, da Silva CH, Venezian GC, Macedo LD, de Souza RF. *Gerodontology 2007;24:162–168.* **References:** 23. **Reprints:** Helena de Freitas Oliveira Paranhos, Department of Dental Materials and Prosthodontics, Riberiao Preto Denta School, University of Sao Paulo, Av. Do Café s/n, 14040-904 Riberirao Preto, Sao Paulo, Brazil. Email: helepar@forp.usp.br—*Beatrice Leung, Toronto, Ontario, Canada*