Maxillary implant-supported overdentures opposed by (partial) natural dentitions: a 5-year prospective case series study

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SUMMARY The aim of this study was to assess the 5-year treatment outcome of maxillary implant-retained overdentures opposed by natural antagonistic teeth. Fifty consecutive patients received maxillary overdentures supported by six dental implants. Implants were placed in the anterior region, if enough bone was present (n = 25 patients) implant were placed in the posterior region if implant placement in the anterior region was not possible (n = 25 patients). Variables assessed included survival of implants, condition of hard and soft peri-implant tissues and patients’ satisfaction. The five-year implant survival rate was 97.0% and 99.3%, and mean radiographic bone loss was 0.23 and 0.69 mm in the anterior and posterior group, respectively. Median scores for plaque, calculus, gingiva, bleeding and mean scores for pocket probing depth were low and stayed low. Patients’ satisfaction after treatment was high in both groups. Within the limits of this 5-year study, it is concluded that six dental implants (placed in the anterior or posterior region) connected with a bar and opposed to natural antagonistic teeth result in acceptable results for clinical parameters and good outcomes for marginal bone level changes and patient satisfaction.

KEYWORDS: prospective studies, dental implants, dentition, denture, overlay, mandible, maxilla

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Introduction

The success of dental implants to support an overdenture is very high (1, 2). It has been presumed that antagonistic natural teeth might reduce the implant survival for implant-retained maxillary overdentures (3, 4). The presence of antagonistic natural teeth is certainly not a contraindication for implant therapy in the maxilla. This view is underlined by the outcome of a systematic review of Ohkubo and Baek (5), showing that there is no correlation between the presence of antagonist teeth and the success of implant overdentures.

There is a lot of knowledge about implant overdentures for the fully edentulous patients (6, 7). However, there are no studies specifically addressing medium survival rate of implants in the edentulous maxilla opposed by natural antagonistic teeth as most studies do not reveal the state of opposing dentition or just mention that all kinds of opposing dentition are present.

Therefore, the purpose of this 5-year prospective case series study was to assess the treatment outcome (survival of implants, condition of hard and soft peri-implant tissues, patients’ satisfaction) of maxillary six implant overdentures opposed by a mandibular natural dentition.

Material and methods

The study design was a prospective cohort study of two parallel groups: the anterior and the posterior
groups. The groups were not compared to each other due to the different positions of the implants in the study groups and the different implant systems used. Comparison of the patients’ satisfaction, on the other hand, seemed justified because overdenture therapy as such was evaluated, and the type of overdenture made was not dependent on the implant system used.

**Patient selection**

Between January 2006 and December 2009, a total of 50 consecutive patients were treated. Twenty-five patients (58.4 ± 8.3 years, range 42–73) received six dental implants in the anterior region of the maxilla, and 25 patients (59.1 ± 9.7 years, range 42–74) received six dental implants in the posterior region of the maxilla to retain a maxillary overdenture.

Patient selection, treatment and 1-year outcome has been described in detail by Slot et al. (8). All patients had natural antagonistic teeth in the mandible (minimum of six teeth present from left lower cuspid to right lower cuspid). In short, these partly edentulous patients suffered from lack of retention and stability of the upper denture and had been referred to the Department of Oral and Maxillofacial Surgery (University Medical Center Groningen, the Netherlands). The patients were at least 1 year edentulous in the maxilla, were non-smoking and had healthy mandibular teeth and a healthy periodontium. Excluded were patients with American Society of Anesthesiologists score ≥ III (9), patients with a history of radiotherapy in the head and neck region, patients with a history of pre-prosthetic surgery and patients with previous implant placement in the maxilla. The patients were informed about the treatment option of overdenture treatment with placing six implants in the maxilla and about the extra efforts associated with the study before they gave their written consent to participate. After consulting the Medical Ethical Committee of the University Medical Center Groningen, it appeared that this case series study was not subject to the Medical Research Involving Human Subjects Act, but only to the Agreement on Medical Treatment Act. The principles outlined in the Declaration of Helsinki were followed in the study.

**Allocation to the anterior group or the posterior group**

If there was an adequate bone volume in the region between the second premolars (assessed clinically and radiologically) to place the implants with adequate primary stability, patients were assigned to the so-called ‘anterior group’.

If there was not an adequate bone volume in the anterior area of the maxilla (in the region between the second premolars), patients were assigned to the so-called ‘posterior group’. Patients in the posterior group received an sinus floor augmentation, 3 months before the implant surgery.

**Treatment procedure**

One experienced oral and maxillofacial surgeon (GMR) performed all surgical procedure. Three experienced prosthodontists did all prosthetic procedures, and an experienced dental laboratory manufactured the superstructures.

**Surgical procedure in the anterior group.** In short, six dental implants with a length of at least 11 mm and a diameter of 4 mm were inserted in the maxillary anterior region* The implants were placed at crestal bone level in pre-defined positions with a surgical template in a two-stage procedure. Small dehiscences were covered with bone harvested from the mandibular retromolar area and anorganic bovine bone† and subsequently with a resorbable membrane‡

**Surgical procedure in the posterior group.** Due to the lack of bone, an augmentation procedure was necessary before implant placement. The augmentation procedure was performed under general anaesthesia, and a bone graft was harvested from the anterior iliac crest (10, 11). For 2 weeks, the patient was not allowed to wear the denture. Then, the conventional denture was relined with a resilient liner§ After a 3-month healing period, six dental implants¶ were inserted in the maxilla into the grafted sites in the posterior area with a surgical template in a one-stage procedure.

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*OsseoSpeed 4.0 S dental implants; Astra Tech AB, Mölndal, Sweden.
†Geistlich Bio-Oss®; Geistlich Pharma AG, Wolhusen, Switzerland.
‡Geistlich Bio-Gide®; Geistlich Pharma AG.
§Soft Liner; GC Corporation, Tokyo, Japan.
¶Straumann Standard SLA® implants; Ø 4.1 mm, length 12 mm, RN; Institut Straumann AG, Basel, Switzerland.
For both groups. Two weeks after implant placement, the patient was allowed to wear their conventional dentures again after adjustment of the prostheses. The conventional denture was adjusted when necessary. After a 3-months osseointegration period, second-stage surgery was performed in the anterior group.

In both the anterior and posterior group, a partial mandibular denture was made simultaneously with the maxillary overdenture in case of a shortened dental arch and when desired by the patient. The maxillary artificial teeth occluded the antagonistic posterior natural or artificial mandibular teeth without disturbing interferences with lateral of protrusive excursions. The overdenture was made without palatal coverage. The final superstructure consisted of a milled titanium bar, screw retained to abutments (for the anterior group) or implants (for the posterior group), and an overdenture with built-in cobalt chromium reinforcement and gold retentive clips attached to it (12). The patient was instructed in hygiene procedures associated with the dentures and the bars and scheduled for routine maintenance recalls at least once a year.

Outcome measures

There were four measuring points (before implant treatment (with the conventional denture) (T0), just after placement of the implants (T1), 1 year after treatment (T12) and 5 years after treatment (T60).

Implant survival. Mobility of implants was checked after removal of the bar at each evaluation period. Loose and lost implants were scored any time after placement.

Change in peri-Implant bone level. Panoramic radiographs was taken at T1, T12 and T60 (Figs 1 and 2).

Clinical parameters. Clinical parameters were scored at T1, T12 and T60.

For the presence of plaque, the index according to Mombelli et al. was used (13) (score 0: no detection of plaque, score 1: plaque can be detected by running a probe across the smooth marginal surface of the abutment and implant, score 2: plaque can be seen by the naked eye, score 3: abundance amount of plaque).

The presence of calculus (score 1) or the absence of calculus (score 0) was scored.

To qualify the degree of peri-implant inflammation, the modified Loe and Silness (14) index was used.

For bleeding, the bleeding index according to Mombelli et al. (13) was used.

After removal of the bar, probing depth was measured at four sites of each implant (mesially, labially, distally and lingually) using a periodontal probe.** The distance between the marginal border of the mucosa and the tip of the periodontal probe was scored as the probing depth.

Patients’ satisfaction. Patients’ satisfaction was scored at T0, T12 and T60.

Patients’ satisfaction was assessed using a validated questionnaire (15). Because there was no lower

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**Merritt-B; Hu-Friedy, Chicago, IL, USA.
denture present questions for the lower denture were left out of the questionnaire. The extent of each specific complaint could be expressed on a four-point rating scale (0 = no complaints; 1 = little complaints; 2 = moderate complaints; and 3 = severe complaints).

Patients’ eating ability with their full denture was assessed using a chewing ability questionnaire (16). This questionnaire focused on how well the patient could eat soft, tough and hard food. There were three possible answers (0 = good; 1 = moderate; and 2 = bad).

The patients’ overall treatment satisfaction was expressed on a 10-point rating scale (1 = very bad to 10 = excellent).

Data collection and statistical analysis
The same observer (WS) collected the data and analysed the radiographs. The worst score per implant of the clinical and radiographic parameters was used in the data analysis. Survival was presented at implant level.

A normality test was done to determine whether our data set was well-modelled by a normal distribution. The scores of the clinical parameters and questionnaires were analysed with (a non-parametric) Wilcoxon matched-pairs signed-ranks test within each of the two groups. Within-group differences for the probing depth at T1, T12 and T60 and overall satisfaction score at T0, T12 and T60 were analysed with (a parametric) paired-sample t-tests. Cases with missing values were excluded analysis by analysis.

Differences between the groups for the questionnaires were analysed by applying the independent-samples Mann–Whitney U-test. Cases with missing values were excluded test by test.

A P-value <0.05 was considered to represent a statistically significant difference. Analysis was done with PASW Statistics 22.0††. In all tests, a significance level of 0.05 was chosen.

Results
Baseline characteristics of the anterior and posterior groups are reported by Slot et al. (8). Mean age was 58.4 years (s.d.: 8.3; range: 42–73) in the anterior group and 59.1 (s.d.: 9.7; range: 42–74) in the posterior group. There were 14 male and 11 female patients in the anterior group and 10 male and 15 female patients in the posterior group. A mandibular partial denture was made for five patients in the anterior group and for six patients in the posterior group.

All patients showed up for the 1-year recall. For the 5-year recall, five patients (three in the anterior and two in the posterior group) were lost to follow-up, viz., one patient moved, two patients refused further participation due to travelling distance to the hospital, one patient deceased and one patient was too ill to attend a recall visit.

Implant survival
During the osseointegration period, three implants were lost in two patients of the anterior group. Because a bar superstructure could still be made on the remaining implants, it was decided not to replace the implants. Another implant was lost after 13 months because of severe peri-implantitis. The bar was adjusted and the patient functioned well without this implant.

In the posterior group, one implant was lost during the osseointegration period. Again, there was no need to replace the lost implant. Thus, 5-year post-loading survival rate of implants was 97.0% in the anterior group and 99.3% in the posterior group.

Change of peri-implant bone level
Bone loss data were not normally distributed. The median peri-implant bone level change between baseline (T1, loading of the implants) and T60 (5-year follow-up) was −0.23 mm [−0.78; 0.00] in the anterior group and −0.69 mm [−1.14; −0.13] in the posterior group (Table 1).

Clinical parameters
The median scores of the indices for plaque, calculus, gingiva and bleeding at T60, but the scores at T60, were significantly worse compared to the scores at T1 (Table 2).

The mean probing depth was 3.8 mm for the anterior group and 3.7 mm for the posterior group at T60. The score improved significantly between T1 and T60 (Table 2).
of the edentulous maxilla, connected with a bar, and opposed by antagonistic natural teeth supply a proper base for the support of a maxillary implant-supported overdenture. The 5-year implant survival rate was high, peri-implant health was acceptable, peri-implant bone loss was low and patients were very satisfied.

In the anterior group, it was expected that in some cases, a augmentation was needed in the same session as implant placement. Therefore, a two-stage implant system was used (17). For the posterior group, a one-stage implant system is used, as it avoids one surgical intervention and shortens treatment time. Comparison between the groups was not possible due to the different implant systems used.

In this study the implant survival was 97.0% in the anterior group and 99.3% in the posterior group. According to the systematic review by Slot et al. (2), the 1-year implant survival rate for six implants with a bar-supported overdenture was 98.2%. Kern et al. describe an estimated survival rate of 98.3% for a conventional prosthesis on ≥four implants (18). In the recent study of Slot et al. (19), the same treatment protocol is used, but then for fully edentulous patients. The implant survival for the anterior group with six implants is 99.2% at T60. The 5-year implant survival rates of the present study are comparable with the survival rate reported in these studies.

The change in peri-implant bone level between T1 and T60 was limited and comparable to those reported by other studies reporting about maxillary bar retained overdentures with a follow-up of 5 years (19–22).

The median scores for plaque, calculus, gingiva and bleeding were very low, both at the 1- and 5-year follow-up. The scores are comparable to those reported

### Table 1. Median values and interquartile range (IQR) with frequency distribution of changes in peri-implant bone level between T1 and T60

<table>
<thead>
<tr>
<th>Group</th>
<th>Anterior group (n = 128 implants)</th>
<th>Posterior group (n = 137 implants)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median [IQR]</td>
<td>−0.23 mm [−0.78; 0.00]</td>
<td>−0.69 mm [−1.14; −0.13]</td>
</tr>
<tr>
<td>0–0.5 mm (%)</td>
<td>56.7</td>
<td>35.3</td>
</tr>
<tr>
<td>&gt;0.5–1.0 mm (%)</td>
<td>10</td>
<td>25.3</td>
</tr>
<tr>
<td>&gt;1.0–1.5 mm (%)</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>&gt;1.5–2.0 mm (%)</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>&gt;2.0 mm (%)</td>
<td>8.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Missing data/implant loss</td>
<td>14.7</td>
<td>8.7</td>
</tr>
</tbody>
</table>

### Patients’ satisfaction

Median scores of the questionnaires focusing on the complaints of the patients and chewing different kinds of foods, together with the mean overall satisfaction score, are listed in Table 3.

All scores improved significantly between T0 and T60, except for ‘aesthetics’ in both groups.

For the posterior group, the score for ‘neutral space’ did not change between T0 and T60.

Differences in patients’ satisfaction between the anterior and posterior group at T0 and T60 are listed in Table 3. At T0, the anterior group scored significantly better on ‘functional complaints about upper denture’, ‘Aesthetics’ and ‘soft food’. There were no significant differences between the groups at T60.

### Discussion

This study demonstrated that six dental implants placed in either the anterior region or posterior region

### Table 2. Median values and interquartile range (IQR) of plaque index (possible score 0–3), calculus index (possible score 0–1), gingival index (possible score 0–3), bleeding index (possible score 0–3) and mean values and standard deviations of probing depth (mm) at T0 and T60

<table>
<thead>
<tr>
<th>Group</th>
<th>Anterior</th>
<th>Posterior</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T0 (n = 25)</td>
<td>T60 (n = 22)</td>
</tr>
<tr>
<td>Plaque index (IQR)</td>
<td>0.0 [0.0; 0.0]</td>
<td>0.5 [0.0; 1.0]</td>
</tr>
<tr>
<td>Calculus index (IQR)</td>
<td>0.0 [0.0; 0.0]</td>
<td>0.0 [0.0; 0.0]</td>
</tr>
<tr>
<td>Gingival index (IQR)</td>
<td>0.0 [0.0; 0.0]</td>
<td>0.5 [0.0; 1.0]</td>
</tr>
<tr>
<td>Bleeding index (IQR)</td>
<td>0.0 [0.0; 1.0]</td>
<td>1.0 [0.0; 2.0]</td>
</tr>
<tr>
<td>Probing depth in millimetre (s.d.)</td>
<td>4.2 (1.2)</td>
<td>3.8 (1.6)</td>
</tr>
</tbody>
</table>

* Significant difference as analysed with a related-samples Wilcoxon signed-ranks test.
† Significant difference as analysed with a paired-samples t-test.
Table 3. Median values and interquartile range (IQR) of five scales concerning the denture complaints (possible range 0–3), chewing ability of soft, tough and hard food (possible range 0–2) and mean score and standard deviation (s.d.) of overall satisfaction score (possible range 1–10) at T0 and T60

<table>
<thead>
<tr>
<th>Group</th>
<th>Anterior (T0 = 25)</th>
<th>T60 (n = 22)</th>
<th>Significance</th>
<th>Posterior (T0 = 25)</th>
<th>T60 (n = 23)</th>
<th>Significance</th>
<th>Differences between groups at T0 and T60</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T0 [n = 25]</td>
<td>T60 (n = 22)</td>
<td>P-value</td>
<td>T0 [n = 25]</td>
<td>T60 (n = 23)</td>
<td>P-value</td>
<td>T0 Significance</td>
</tr>
<tr>
<td>Functional complaints about upper denture (IQR)</td>
<td>2.4 [1.7; 2.4]</td>
<td>1.1 [1.1; 1.2]</td>
<td>P = 0.000*</td>
<td>2.4 [2.2; 3.0]</td>
<td>1.1 [1.1; 1.3]</td>
<td>P = 0.000*</td>
<td>P = 0.027*</td>
</tr>
<tr>
<td>Functional complaints in general (IQR)</td>
<td>1.8 [1.5; 2.1]</td>
<td>1.0 [1.0; 1.1]</td>
<td>P = 0.000*</td>
<td>2.0 [1.7; 2.3]</td>
<td>1.1 [1.0; 1.2]</td>
<td>P = 0.000*</td>
<td>P = 0.235</td>
</tr>
<tr>
<td>Facial aesthetics (IQR)</td>
<td>1.7 [1.0; 2.0]</td>
<td>1.0 [1.0; 1.1]</td>
<td>P = 0.000*</td>
<td>2.0 [1.3; 3.0]</td>
<td>1.0 [1.0; 1.7]</td>
<td>P = 0.003*</td>
<td>P = 0.076</td>
</tr>
<tr>
<td>‘Neutral space’ (IQR)</td>
<td>1.7 [1.0; 2.0]</td>
<td>1.0 [1.0; 1.0]</td>
<td>P = 0.001*</td>
<td>1.9 [1.0; 1.7]</td>
<td>1.0 [1.0; 1.1]</td>
<td>P = 0.052</td>
<td>P = 0.037*</td>
</tr>
<tr>
<td>Aesthetics (IQR)</td>
<td>1.0 [1.0; 1.3]</td>
<td>1.0 [1.0; 1.0]</td>
<td>P = 0.038*</td>
<td>1.3 [1.0; 1.7]</td>
<td>1.0 [1.0; 1.4]</td>
<td>P = 0.002*</td>
<td>P = 0.028*</td>
</tr>
<tr>
<td>Soft food (IQR)</td>
<td>2.3 [1.7; 2.5]</td>
<td>1.0 [1.0; 1.0]</td>
<td>P = 0.000*</td>
<td>1.0 [1.7; 2.7]</td>
<td>1.0 [1.0; 1.4]</td>
<td>P = 0.000*</td>
<td>P = 0.930</td>
</tr>
<tr>
<td>Tough food (IQR)</td>
<td>3.0 [2.5; 3.0]</td>
<td>1.0 [1.0; 1.8]</td>
<td>P = 0.000*</td>
<td>3.0 [2.3; 3.0]</td>
<td>1.0 [1.0; 1.7]</td>
<td>P = 0.000*</td>
<td>P = 0.888</td>
</tr>
<tr>
<td>Hard food (IQR)</td>
<td>4.5 [5.6; 6.8]</td>
<td>8.6 [6.9]</td>
<td>P = 0.000*</td>
<td>3.7 [1.6]</td>
<td>8.5 [0.9]</td>
<td>P = 0.000*</td>
<td>P = 0.680</td>
</tr>
</tbody>
</table>

*Significant difference as analysed with a related-samples Wilcoxon signed-ranks test.
†Significant difference as analysed with an independent-samples Mann–Whitney U-test.
§Significant difference as analysed with a paired-samples t-test.

4.0 S dental implants were used, although applied in the mandible and maxillae (23) and Meijer et al. (24) in which the same criteria were used and in which also Osseospot SLA implants were used, although applied in the mandible and maxillae.

The overall satisfaction score improved significantly for both groups (s.d.: 0.9) for the anterior group and from 3.7 (s.d.: 1.6) to 8.5 (s.d.: 0.9) for the posterior group (from 3.7 [1.6] to 8.5 [0.9]). The probing depth got significantly lower over time for both groups (from 4.5 [s.d.: 1.5] to 8.6 [s.d.: 0.9]) and well within the healthy range (13, 14). The probing depth was within the healthy range (27) at T1 and even got a bit less deep at T60, meaning that the tissues stayed healthy.
procedure. In a recent publication, Slot et al. (19) describe that, for edentulous patients, after 5 years, the treatment outcome for an overdenture on four implants in the anterior region is not inferior to overdentures supported by six implants. The only difference between the study of Slot et al. and this study is the presence of teeth in the mandible. The good results of the overdentures on six implants, as described in this study, suggest that further research for maxillary overdentures opposing natural dentitions could focus on the possibility of placing four implants to support the overdenture instead of six.

Conclusion
Within the limits of this 5-year study, it is concluded that six dental implants (placed in the anterior or posterior region) connected with a bar and opposed to natural antagonistic teeth result in acceptable outcomes for clinical parameters and good outcomes for marginal bone level changes and patient satisfaction.

Funding
External unrestricted funding was obtained from Astra Tech AB, Mölndal, Sweden and Institut Straumann AG, Basel, Switzerland.

Ethical approval
After consulting the Medical Ethical Committee of the University Medical Center Groningen, it appeared that this case series study was not subject to the Medical Research Involving Human Subjects Act, but only to the Agreement on Medical Treatment Act. The principles outlined in the Declaration of Helsinki were followed in the study.

Conflict of interest
Dr. Boven, Dr. Vissink, Dr. Raghoebär, Dr. Meijer, and Dr. Slot reports other from Astra Tech AB, Mölndal, Sweden and Institut Straumann AG, Basel, Switzerland, during the conduct of the study.

References

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