Success Rates of Microimplants in Edentulous Patients with Residual Ridge Resorption

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Purpose: *Restorative therapy of edentulous mandibles with residual ridge resorption is still a great challenge. Even though implant-supported stabilization of dentures has proved to be of value in these cases, treatment is sometimes problematic, not only due to narrow width of the denture-bearing areas but also because elderly patients are often averse to surgery. Implants with a normal length but a reduced diameter might facilitate therapy in patients with implant-supported dentures. The aim of the present study was to evaluate the clinical success of implants with a small diameter.* ***Materials and Methods:*** *In a prospective study, patients were provided with 2 implants 2.5 mm in diameter (MicroPlant; Brasseler, Lemgo, Germany) in a 2-stage procedure in the intraforaminal area of the edentulous mandible. Subsequently, the patients were monitored in periodic recalls. Periotest value, Gingival Index, and attachment level were monitored at these recall evaluations. Peri-implant bone loss was measured using panoramic radiographs. Patients rated the functionality of their denture using questionnaires administered before and after treatment.* ***Results:*** *Sixty-seven patients were monitored during an average observation time of 6 years (SD 2.7). The cumulative survival rate of the implants was 95.5%. Clinical and radiographic parameters yielded results comparable to those of implants with a larger diameter. The questionnaire revealed sharp and significant improvement in denture retention and chewing ability after denture stabilization with the implants.* ***Conclusion:*** *The clinical data and the results of the questionnaire clearly indicated that the patients were satisfied with the concept of stabilization of complete mandibular dentures with small-diameter implants.* (Case Series)
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Key words: *dental implants, elderly patients, implant-supported dentures, magnetic abutment, narrow implants, O-ring abutment, severe ridge resorption, slightly raised ridges*

Edentulous patients with severe residual ridge resorption frequently complain about poorly fitting, loose dentures,[1,2] even if these were manufactured according to the state of the art. This problem is caused by level or only slightly raised alveolar ridges, which allow undesirable shifting of the dentures even when only minor horizontal forces are applied. Implant-supported dentures can lead to considerable improvement by preventing horizontal shifting and stabilizing the restoration.[3] However, narrow denture-bearing areas with equally narrow firmly attached gingiva often necessitate supplementary therapy. Elderly patients are often averse to surgical treatments or expensive and drawn-out therapies. Implants with a reduced diameter, however, offer certain benefits that might dispel patients' reservations. By applying implants that are normal in length but have a diameter of only 2.5 mm, the surgical procedure can be limited to inserting the implant. Additional interventions such as vestibuloplasty, excessive reduction of narrow bony ridges, or alveolar bone grafting become redundant.[4] The omission of peri-implant surgery, together with the simple integration of the implants into complete dentures, minimizes the duration of the treatment and makes it more affordable. Although they have some obvious advantages, reduced-diameter implants feature some biomechanical characteristics that have to be analyzed. Given that reduced-diameter implants have a smaller surface than conven-

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tional implants, the load transferred to the bone-implant interface by a horizontal force is greater in narrow implants than in conventional implants.[5,6] As the bite force decreases from posterior to anterior,[7] placing the implants in the anterior area of the dental arch may compensate for potential pressure peaks. Likewise, shorter attachments may result in lower bending moments. The way in which these pros and cons affect the clinical success of reduced-diameter implants is unknown. There is a lack of studies on the clinical outcome of implants with a diameter of 2.5 mm or less. Only a few studies on implants of a diameter of 3.4 mm or less and on overdentures supported by narrow implants are available.[4,8–10] The aim of this study was to examine whether clinical and radiographic parameters indicate stable osseointegration of reduced-diameter implants and whether dentures can be sufficiently stabilized by 2 reduced-diameter implants to meet patients' demands on well-fitting dentures.

Fig 1 MicroPlant implant of 12 mm length with o-ring and magnetic attachments.

MATERIALS AND METHODS

Clinical Treatment

The research protocol applied in this investigation was designed for a prospective study. The protocol was approved by the ethics committee of the medical faculty of the University Erlangen-Nuremberg. All participants were recruited from edentulous patients who had been provided with complete dentures at the university dental clinic. If the patients were unsatisfied with the results of the rehabilitation although an accurate treatment procedure had been performed, implant-supported partial dentures were recommended. As many participants as possible were included in the study. The inclusion criterion was the presence of an edentulous mandible with severe ridge resorption (ie, the ridge had to be either completely level or only slightly raised). Exclusion criteria were local or general diseases that could have compromised implant treatment.[11] No restrictions concerning age or gender of the participants were imposed. Two reduced-diameter implants (MicroPlant; Komet Brasseler Group, Lemgo, Germany) including sealing caps were placed in the area of the lateral incisors or canines of the anterior mandible using a surgical template. These screw-type implants had a diameter of only 2.5 mm (Fig 1) and lengths of 9 mm, 12 mm, or 15 mm. The implant surfaces had been sandblasted and coated with calcium phosphate (Bonit; DOT Medical Implant Solutions, Rostock, Germany). Prior to the implant surgery, the implant-supported areas of the denture bases were reduced by at least 2 mm and relined with soft denture liners to avoid loading of the implants and the peri-implant bone. Three to 4 months after insertion of the implants, the sealing caps were uncovered and removed. Subsequently, male attachments of appropriate size were inserted. After receiving detailed information and expert advice on technical properties and proper handling of the attachments, the patients were asked to choose magnetic or o-ring attachments (Fig 1). The male attachments were fastened by means of a torque ratchet with a moment of 13 Ncm. The female attachments were polymerized into the denture during the same treatment session.

Examination Protocol

The first clinical evaluation took place 2 to 3 days after surgery, followed by another evaluation at the time of suture removal after 7 days, and then again after 3 and 7 weeks. A timetable of the scheduled follow-up examinations is shown in Table 1. Starting from the time the denture was attached to the implants (ie, from the time of attachment fixture and fitting) the Periotest value (Gulden Medizintechnik, Bensheim, Germany) and the attachment level according to Quirynen et al[12] were recorded. Since Periotest values depend on the location and direction of the pulse impact, the probe was applied at the widest point of the attachment. As suggested by the instruction manual, the measurement was performed with the jaw in a horizontal position. The attachment level was measured mesially and distally using a periodontal probe; slight pressure was applied. All measurements were taken by the same investigator throughout the study. Digital panoramic radiographs (Orthophos DS Plus; Sirona, Bensheim, Germany) with a resolution of 3 lines/mm were obtained following implant placement; these radio-

Table 1 Timetable of Follow-up Examinations

Event	Time
Implant surgery	
Control of lesion	2 to 3 days after surgical intervention
Removal of sutures	7 days after surgical intervention
Control of denture	3 weeks after surgical intervention
Control of denture	7 to 8 weeks after surgical intervention
Uncovering of the implants and first FUE	3 to 4 months after surgical intervention
Second FUE	14 days after uncovering
Third FUE	8 weeks after uncovering
Fourth FUE	6 months after uncovering
Periodic FUEs after that date	At 6-month intervals

FUE = follow-up examination.

Table 2 Frequency of the Different Implant Lengths

Implant length	No. placed (n = 134)	%
9 mm	22	16.4
12 mm	82	61.2
15 mm	30	22.4

Table 3 Frequency of the Different Attachment Lengths

Attachments	No. placed (n = 130)	%
L1	51	39.2
L2	55	42.3
L3	24	18.5

L1 was applied in case of a mucosa thickness of 1.5 mm, L2 in case of a mucosa thickness of 2.5 mm, and L3 in case of a mucosa thickness of 3.5 mm.

graphs served as a reference to determine the periimplant bone resorption. Further radiographs were performed in yearly intervals. Measurement of the Gingival Index according to Loe and Silness[13] started after healing of the mucosal lesion caused by uncovering the implant and was repeated at every follow-up examination. Patients were given questionnaires using visual analog scales to assess their satisfaction with the denture with respect to denture retention and chewing ability. The endpoints of the visual analog scale were 0 (totally dissatisfied) and 10 (excellent). The first questionnaire was completed prior to implant stabilization, and a second, identical questionnaire was completed about 6 weeks after connecting the mandibular denture to the implants via the attachments. For the statistical analysis, a 2-sided nonparametric rank test according to Kruskal-Wallis was applied using Stat View + on an Apple Macintosh OS 9.2. A coin-flip method was used to perform a random selection of the 2 implant groups.

RESULTS

Implant Placement

From January 1997 to March 2006, 67 participants were provided with implants according to the study protocol. No antibiotic therapy was administered during implant surgery. At the time of implant surgery the patients' age ranged between 53 and 83 years, with a mean age of 69 years (SD = 7). The different lengths of the implants were chosen individually for each patient depending on the amount of bone available vertically (Table 2). Forty-seven participants (70.1%) chose the magnetic attachment, and 20 participants (28.9%) chose the o-ring attachment. The lengths of the attachments were selected to suit the thicknesses of the mucosa (Table 3).

Survival Analysis

The implants had a mean time in situ of 6.0 years (SD 2.7 years). To estimate the cumulative survival rate, a Kaplan-Meier analysis was made, involving the clinical parameters for treatment success suggested by Albrektsson et al.[14] Since the Kaplan-Meier procedure requires a random sample of independent data, only 1 of the 2 implants of each patient was randomly selected to form a group (group A). The remaining implants also represented a group of independent data. Therefore, these implants were combined to form a second group (group B). Of the 134 implants, 2 were lost in group A, and four were lost in group B, yielding cumulative survival rates of 97.0% and of 94.0%, respectively (Fig 2). Averaging the cumulative survival rate of groups A and B resulted in a cumulative survival rate of 95.5%. The following reasons were

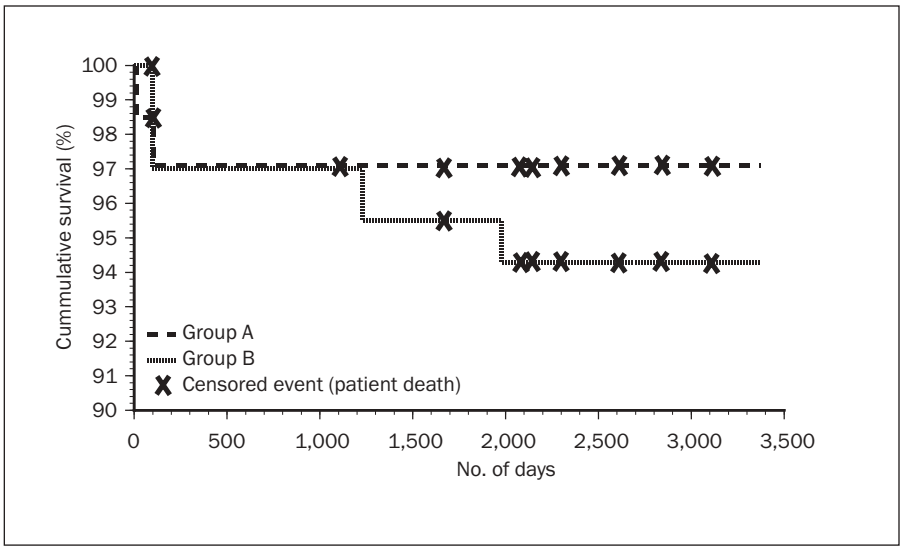

Fig 2 Kaplan-Meier analysis of the cumulative survival rate.

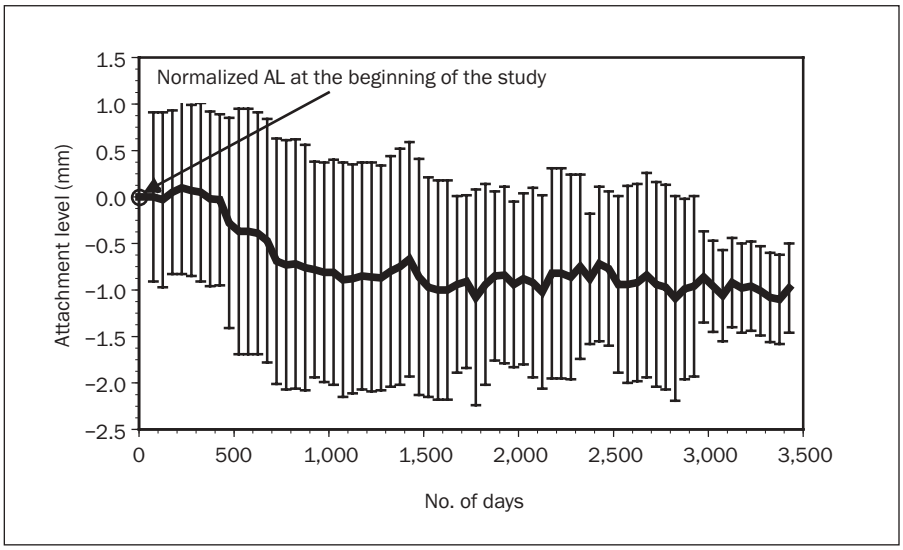

Fig 3 Time-dependent trend of the attachment level.

established for the failures: One implant had to be removed after 7 days because of enduring pain of unclear origin. Three implants were mobile after uncovering and could be removed painlessly. Two implants were associated with advanced bone resorption in the fourth and sixth years, resulting in loss 11 to 17 months later. In the 6 affected patients, the implants were successfully replaced but were excluded from the study. Impaired sensibility or other complications (eg, fracture of the narrow implants) were not observed.

Clinical and Radiological Evaluation

After uncovering the implants and setting of the male attachments stability was evaluated with the Periotest. In this session a mean Periotest score of −1.3 (SD 1.1) was ascertained. During the first year the Periotest scores stabilized; from this point onward, they remained fairly constant.

A mean Gingival Index score of 0.4 (SD 0.4) was observed, with a maximum score of 2. However, even at grade 2 no bleeding occurred during probing. During the entire observation period no significant deviations from this average occurred. Plaque accumulation and calculus were mostly found in the lingual concavity of the primary attachments. Purulent inflammations or signs of peri-implantitis did not occur in any of the patients, not even in those 2 who experienced implant loss after the fourth and sixth year.

To illustrate the time-dependent development of the attachment level, the values were normalized to zero at the start of the evaluation. Determination of the clinical attachment level revealed a mean loss in height of about 1 millimeter (Fig 3) within the first 2 years. After this time no statistically significant decrease was observed ($P > .05$).

The panoramic radiographs revealed a mean reduction of the peri-implant bone of 0.5 millimeters

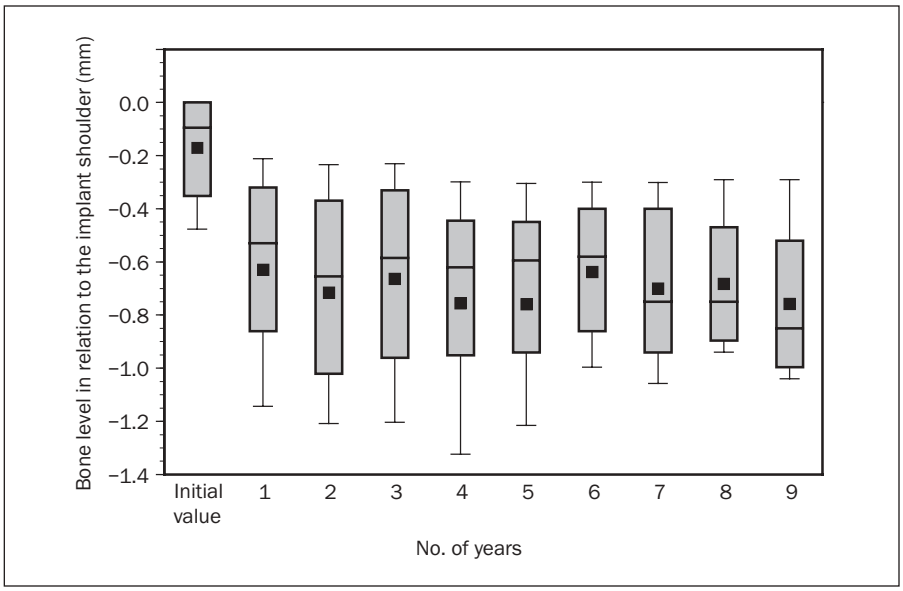

Fig 4 Bone level evaluation based on panoramic radiography. The lines represent the medians; the squares, the means.

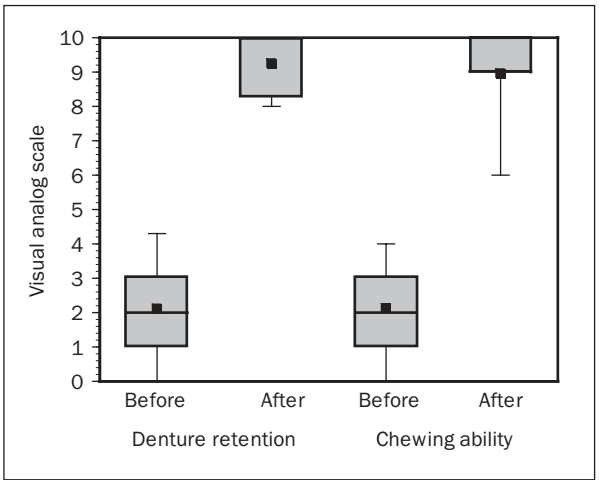

Fig 5 Results of questionnaire assessing the satisfaction of the patients with the denture. Zero indicated "totally dissatisfied"; 10 indicated "excellent."

(SD 0.4) during the first year and another 0.2 millimeters (SD 0.3) in the second year (Fig 4). In the following years no further bone resorption leading to significant differences to the mean of the second year was observed ($P > .05$).

Questionnaire

Before implant stabilization, patients tended to be dissatisfied with the function of their dentures, although these were accurately made and free of defects (Fig 5). Due to the problems associated with level or only slightly raised ridges, the visual analog scale scores for denture retention and chewing ability scored mean values of only 2.0 (SD 1.5) and 2.1 (SD 1.4), respectively. However, after connecting dentures to the osseointegrated implants, a strong and significant increase of satisfaction was observed. Postloading, a mean score of 8.4 (SD 1.3; $P < .001$) was found for denture retention, and a mean score of 9.1 (SD 1.2; $P < .001$) was found for chewing ability.

DISCUSSION

Except for 9 persons who passed away during the observation period (censored event), all patients participated in the periodic recalls. The results can therefore be regarded as representative.

There is little information in literature concerning the long-term clinical performance of reduced-diameter implants. Consequently, the present results can only be compared to studies of implants with a wider diameter and to systematic literature reviews on implant survival. Straumann implants with a 3.3-mm diameter reportedly achieved cumulative survival rates of 96.4% after 1 year being subjected to clinical loading by overdentures.[9] A further study on this implant diameter revealed 5- to 6-year survival rates of 98.7% or 96.6% for single-tooth restorations and stabilization of overdentures, respectively.[4] The cumulative survival rates of 97.0% (group A) and 94.0% (group B) of the reduced-diameter implants observed in the present study are consistent with the results of a systematic literature review with pooled data of a total of 7,398 implants.[15] This review reported a 5-year survival of 96% with a confidence interval of 93% to 98%.

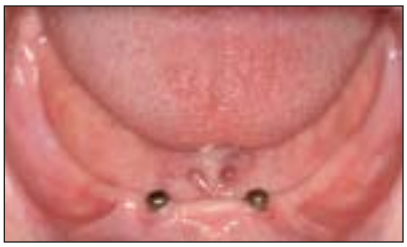

Fig 6 Typical jaw conditions of patients provided with reduced-diameter implants.

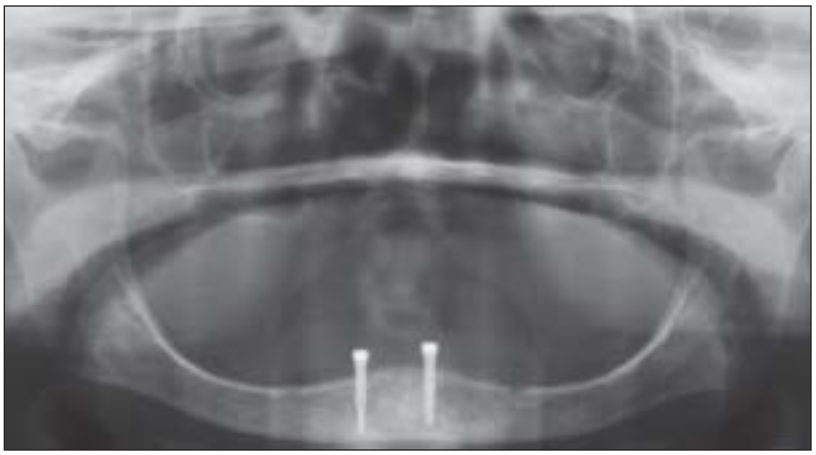

Fig 7 Panoramic radiograph of the situation in Fig 6.

The lack of osseointegration found in 3 implants after uncovering may have been due to a combination of factors during healing phase: increased shifting of the denture facilitated by flat ridges and excessive loading caused by bruxism.[16] Therefore, avoidance of loading of the anterior dental arches by reducing the denture base in the implant area as required by the study protocol is necessary. Furthermore, equilibrating the occlusion with sufficient freeway space in the incisor area would be advantageous.

According to Davarpanah et al[17] reduced-diameter implants show an increased risk of fracture. The absence of implant fracture in the present study indicates that overloading of reduced-diameter implants were avoided through observance of the study protocol, particularly the placement of implants in the anterior mandible and the use of short attachments.

Compared to a dental radiographic film the panoramic radiograph is only of limited reliability for the assessment of bone resorption around implants. The progression of bone loss could have been demonstrated more clearly by means of an intraoral radiograph.[18] However, given the severe ridge resorption and the small heights of the male attachments, orthoradial shots perpendicular to the implant axis were not practicable in the anterior area of the mandible. Because of the muscles on the floor of the mouth and the jawbone, the prescribed positioning of individual or standardized film holders proved impossible.[19] Therefore, panoramic radiographs were used despite their limited reliability. The peri-implant bone resorption associated with reduced-diameter implants was comparable to that experienced with established implant systems; resorption ranged from 0.5 mm to 1 mm in the first year and showed a mean progression of 0.1 mm in the following years.[12,20,21]

Examination of the clinical attachment level yielded results similar to the radiographic evaluation.[22,23] With a loss of 1 mm during the first 2 years, the decrease of attachment was greater than the value established in another investigation, which reported a loss of 0.4 mm after 1 year.[24] However, the authors of the other investigation started collecting data upon completion of the prosthetic treatment, 10 to 12 weeks after uncovering of the implant, whereas in the present study evaluation of attachment loss began 2 weeks after uncovering of the implant. The trend of the attachment loss seemed to follow the radiographic findings with a certain time lag (Figs 3 and 4). Although the evaluation of attachment loss may not be as exact as a radiographic investigation, it represents a simple screening method that allows the clinician to monitor the condition of the implants in periodic recalls.[23]

As in other studies, the assessment of implant mobility with the Periotest device yielded negative values.[20] The decrease to a constant median score of –3.2 took place over a period of 1 year, which coincides with the findings of other authors.[20] As the Periotest measurement was taken at the abutment, the stabilization could partly be due to strengthening of the bone-implant interface and partly to the reinforcement of the screw joint. An important factor for the success of stabilizing dentures with implants may be the special selection of unfavorable denture-bearing tissue with narrow and only slightly raised ridges. An example of typical jaw conditions is shown in Figs 6 and 7. The highly positive rating in the questionnaire concerning the stabilization of implants is probably partly due to this specific selection of cases and confirms the results of other authors in conditions similar to those in this investigation.[25]

CONCLUSION

Providing edentulous patients suffering from severe ridge resorption with reduced-diameter implants was a successful treatment method. Regarding this particular indication, the implant survival of the reduced-diameter implants was identical to the survival of standard implants. The results of the questionnaire confirm that stabilization of mandibular dentures with reduced-diameter implants leads to considerable improvement of function of the prosthesis and increased comfort for the patient.

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