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Original article

Mini dental implants retaining mandibular overdentures: A dental practice-based retrospective analysis

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ABSTRACT

Purpose: The purpose of this study was to assess the survival of mini dental implants (MDI) and to measure prosthetic maintenance needs in a dental practice-based setting.
Methods: Patients with mandibular removable dentures were provided with MDI to improve denture retention. Complications and maintenance were analyzed by use of patient records and evaluated with Kaplan–Meier curves and the log rank test at a significance level of 0.05.
Results: Ninety-nine MDI were placed in 25 patients (mean age: 72 years). Two MDI fractured during placement and eight implants failed during the first weeks. No more implants were lost for up to seven years, resulting in 92% survival. Implant survival differed significantly depending on whether the maxilla was provided with complete dentures (94.9%) or with partial dentures (81%). All prostheses were in use at the time of data extraction. Denture base fractures were observed in six cases, an incidence of fractures of 24%. Some minor intervention was necessary: one resin tooth fractured, retention rings were changed in five cases, and repeated relining was required for 16% of the dentures.
Conclusions: After mid-term observation, survival of MDI was good. However, the incidence of denture base fractures and of minor prosthetic complications should not be under-estimated.

1. Introduction

Poor retention of mandibular complete dentures can result in severe patient dissatisfaction. Placing of two implants is currently regarded as the treatment of first choice to improve prosthesis retention [1]. This concept has been widely studied and its success is generally accepted, with regard to not only implant performance but also patient satisfaction [2]. Evidence is available for different attachment systems, for example balls and bars, with favourable results for both [3].

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However, placing of two regular implants is costly treatment, and patients express their reluctance and fear of the surgery and of subsequent pain, especially when two full-thickness flaps are raised [4]. Therefore, minimally invasive and less expensive alternatives have been developed, for example placing a single implant in the mandibular midline [5] or insertion of mini dental implants (MDI) [6].

MDI are small implants of diameter <3 mm [6]. They have self-cutting threads and can be inserted without gingival flap elevation. They are usually one-piece implants with prosthetic attachments in different shapes, for example tapered abutments or balls. For the mandible, an immediate loading concept is promoted by the manufacturers. First results are indicative of promising implant survival [6,7]. It must be remembered that, although four or more implants are recommended for the edentulous mandible, implant retention, only, is achieved. Chewing forces are exerted both on the MDI and also on the mucosal tissues in the posterior areas.

Important information on MDI, for example long-term survival [6] or success [8], is not available. Particularly valuable for practitioners are data for patients treated in conventional dental practices [9]. The purpose of this retrospective analysis was, therefore, to increase the amount of information available on MDI by evaluating survival and maintenance needs from the perspective of practice-based treatment.

2. Materials and methods

2.1. *Treatment rationale*

This analysis was based on patients from two dental practices in Germany and Luxembourg which documented all MDI placed to retain mandibular overdentures between 2008 and 2015. Patients were treated with MDI if they fulfilled two inclusion criteria: they had worn removable prostheses for years and were dissatisfied with the retention of their dentures. The patients' medical histories were checked for absolute implant contraindications as described by Hwang et al. [10], for example active treatment of malignancy, drug abuse, psychiatric illness, or intravenous bisphosphonate prescription. The concept to improve retention for complete denture wearers was to place four MDI in the interforaminal area. For partial denture wearers, MDI were implanted in strategic positions to support free-end-saddles. The MDI (3M Espe, Seefeld, Germany) were loaded immediately after implantation. Only collared O-Ball implants (OB, IOB and MOB; 3M Espe) were used. The corresponding housings were integrated into the old dentures. All implants were placed by the same dentist in a conventional dental practice.

2.2. *Implantation and prosthetic loading*

Digital radiological imaging (2D panoramic X-rays) was performed and a standardized test specimen was used to assess bone height; MDI length was chosen accordingly. After clinical investigation, implant diameter was selected from three possible diameters, 1.8 mm (OB), 2.1 mm (IOB), and 2.4 mm (MOB). Bone augmentation procedures were not performed. Patients were informed about benefits, risks, and costs by the treating dentist, a general practitioner without specialization in implantology. Implants were placed under local anaesthesia without flap elevation. A pilot drill was used to prepare the implantation site, as recommended by the manufacturer, for half the implant length in hard bone. The self-cutting implants were screwed into the mandible with the objective of primary stability of at least 35 Ncm, tested with a torque gauge. After implantation, the housings for the ball attachments were integrated into the dentures by use of Ufi Gel hard C (Voco, Cuxhaven, Germany). Oral hygiene was explained and demonstrated. A recall session was scheduled for approximately two weeks after implantation and a relining session six weeks after implantation.

2.3. *Study design and data analysis*

This retrospective study was performed to evaluate implant and denture survival, and prosthetic maintenance requirements. It was part of internal quality assessment conducted to analyze MDI treatment success. It was designed as a purely observational study in which the type of intervention was not determined by the investigator. Patients were treated in the regular manner of the practices.

Digital patient records were used to gather information with the help of a data-extraction sheet. The following aspects were evaluated: patient age, sex, date of implantation, MDI number, implant length and diameter, complications during surgery, implant loss, maxillary restoration, maintenance sessions and aftercare needs. MDI treatment was introduced as a therapy in the practices in 2008. The records of all patients which had been treated since then were included into the analysis. Statistical analysis was performed with SPSS 22 (IBM, Armonk, USA). Patient and implant characteristics were evaluated by use of descriptive statistical methods. Kaplan–Meier curves were computed for survival analysis. Log rank tests were used to assess the effect of maxillary restoration. A p value <0.05 was regarded as indicative of statistical significance.

3. Results

3.1. *Patient characteristics*

Twenty-five patients have been treated with MDI-retained mandibular dentures since 2008. All patients were included into this analysis. However, one patient deceased in the course of the study. The patients gave information on their medical histories, comprising hypertension (4 patients), cardiac defect (1 patient), arrhythmia (1 patient), stroke (1 patient), allergies (2 patients), and hypothyroidism (3 patients). Twenty-one complete dentures and four unilateral cantilever RDP were retained by MDI. Of the four RDP, three were attached to one residual tooth only and one was retained by seven residual teeth with a unilateral long free-end-saddle. The mean age of the patients at implantation was 72 years (range 51–87 years). In the maxilla, patients were provided with complete dentures (n = 19 patients), with RDP (n = 5), and with an FDP in one case. Sixty-eight percent of the patients were female. Ninety-nine MDI were placed; implant lengths were 10, 13, 15, or 18 mm. Implant diameters ranged between 1.8 and 2.4 mm (Table 1).

Table 1 – Diameters and lengths of the 99 implants and the 2 MDI that fractured during insertion.

Implant diameter [mm]	Number	%	Diameters of the failed implants
Not documented	4	4.0	
1.8	68 + 2	69.3	6
2.1	7	6.9	2
2.4	20	19.8	2
Total	99 + 2 = 101	100	10
Implant length [mm]	**Number**	**%**	**Lengths of the failed implants**
Not documented	4	4	1
10	17	16.8	1
13	14	13.9	
15	50 + 2	51.5	8
18	14	13.8	
	99 + 2 = 101	100	10

3.2. *Implant survival*

Mean observation time was 33 months, range 2–87 months. In the case of the deceased patients, all MDI were in situ without failure at the time of death. Therefore, survival data was entered from implantation to this time point. During insertion of the implants, two MDI fractured, resulting in immediate incidences of complications of 2% on implant level and 8% on patient level. Post-operation complications relate to implant exfoliation during osseointegration (mean time: 68.4 days = 9.7 weeks, range 11–186 days). Eight of the 99 MDI were lost, resulting in survival of 92%. Once osseointegrated, no more implant losses were observed for up to seven years.

Implant survival was analyzed separately for different types of maxillary restoration in the opposing arch. Of the 99 MDI, 78 were inserted with a complete denture in the maxilla whereas 21 were inserted with an RDP or FDP in the opposing jaw. Of the eight implants lost, four were in the first group and four in the second group, i.e. survival was 94.9% and 81%, respectively. Kaplan–Meier curves were used to model implant survival in both groups (Fig. 1). The log-rank test revealed a significant difference ($p = 0.025$) between implant survival in the two groups, indicating a significant effect of maxillary restoration on implant survival.

In total, 21 complete dentures and 4 RDPs were improved by MDI placement. In the RDP group, 11 MDIs were placed whereas there were 88 in the complete denture group. The eight failed implants were distributed equally in both groups (4 failures each). The difference in survival was analyzed with the log rank test and a significant difference was found ($p < 0.001$).

3.3. *Prosthetic complications*

After an observation period of up to seven years, all prostheses were still in use. Prosthetic maintenance of MDI-retained overdentures must not be underestimated, however. Denture base fractures were observed in six cases (24%; Table 2). It must be stated that only old dentures were used; some of these contained a metal framework which had to be reduced to integrate the housings. A single relining, six weeks after implantation, was recommended to all patients; it was performed for 14 patients only, however, indicating less relining was needed than was expected beforehand. Nevertheless, four of these 14 dentures required additional relining (16% of the dentures).

Table 2 – Prosthetic complications and maintenance.

Complication	Single event	Multiple events	Incidence
Relining	10	4	14/25 = 56%
Exchange of rings	5		5/25 = 20%
Denture base fracture	5	1	6/25 = 24%
Resin tooth fracture	1		1/25 = 4%

Eight dentures (32%) required multiple maintenance sessions (because of a variety of complications, for example fractures, relining, and resin tooth damage) with involvement of a dental laboratory; this might be regarded as more troublesome for patients and dental staff than, for example, a single, previously planned relining procedure.

4. Discussion

This analysis of results from a dental practice found MDI survival was 92% after up to seven years. As far as the authors are aware, only three studies have already reported a follow-up period of five years or more [6,9,11,12]. For the cohort investigated the mean age was high, 72 years, indicating this treatment rationale was well accepted by elderly patients. All failing implants were lost during the first weeks after placement. Maxillary restoration seems to affect MDI survival. It is interesting to note that evidence on flapless insertion of MDI is rather limited [7]. Sohrabi et al. concluded from their review on small-diameter implants that more studies should be conducted on flapless techniques [7].

The retrospective design of this analysis is a major limitation. Although digital patient records were available and all events had been thoroughly documented, it is possible that complications—especially prosthetic complications—might have been underestimated. Furthermore, conclusions must be reached with care, because the number of patients was limited and the follow-up period was broad, ranging from 2 to 87 months. Ninety-nine MDI is sufficient for informative statistical testing, however. This report is also of relevance because of its practice-based setting, and the fact that all implants were placed by one general dentist only, preventing inter-operator bias.

Two MDI fractured during implantation. In both cases, the residual parts of the fractured MDI were left in the mandibular bone. In the literature, MDI have been associated with an increased risk of fracture in clinical practice [13] and have been reported to be sensitive to high insertion torque. Bidra et al. reported the need to substantially reduce insertion torque compared with standard implants [6]. For orthodontic mini implants, tapered designs, as used in this study, withstand significantly less torque than non-tapered designs [14]. Therefore—especially in hard bone—preconditioning of the

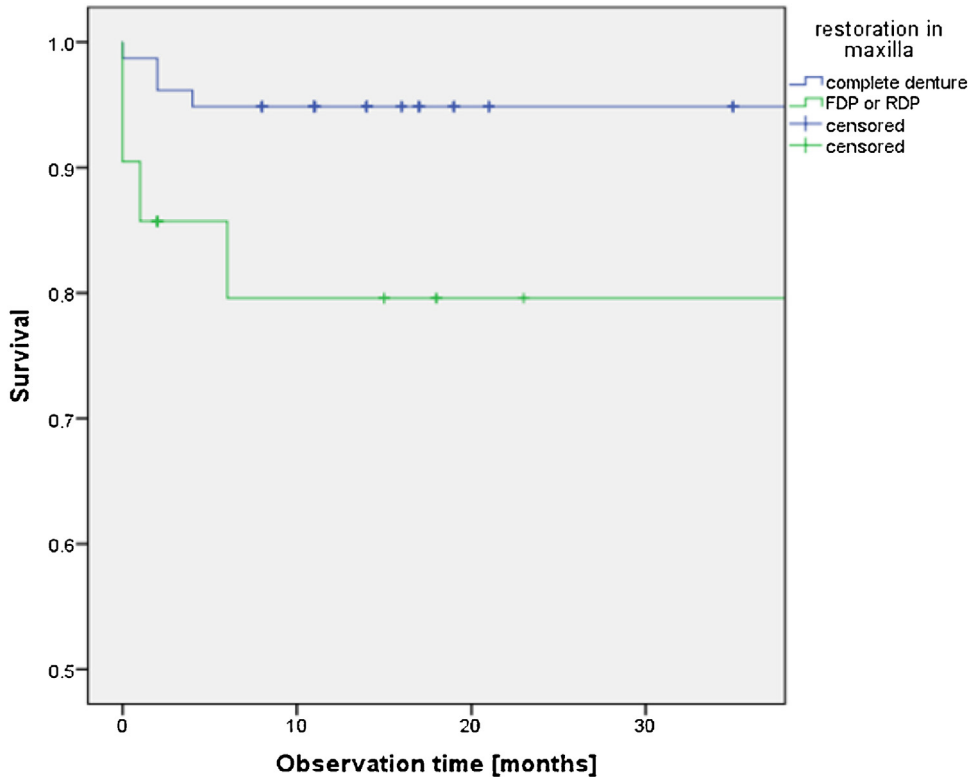

Fig. 1 – Kaplan–Meier-curves for implant survival. The blue line indicates implants with a complete denture in the maxilla whereas the green line represents mandibular implants with FDP or RDP in the opposing arch. The log-rank test revealed a significant difference ($p = 0.025$) between the two groups.

implant site is mandatory, by using a pilot drill to 1/2 or 1/3 of the implant length, depending on bone density (D1, D2, or D3). MDI fracture is a major problem in comparison with the incidence of fractures for regular-diameter implants, which has been computed to be approximately two fractures per 1000 implants [15].

Eight MDI were lost during the first year, resulting in overall survival of 92%, and 94.9% for patients with a complete maxillary denture. Retrospectively, we can only speculate about the reasons for the failures. Given that restoration of the opposing maxilla was found to affect MDI survival, overloading during osseointegration seems to be a risk factor. Wearing complete dentures has been reported to decrease maximum bite force [16–18]. As a consequence, the better MDI performance with antagonist complete dentures might be caused by the reduced load and stress on MDI. A similar pattern was found by Jofré et al.: in a randomized trial, they compared two MDI attachment systems for mandibular overdenture retention—balls and bar [19]. Two-year survival was 97.8% in the bar group and 90.9% in the ball group, indicating better survival after splinting. Splinting increases resistance against dislodging forces and thus reduces stress on MDI and on the bone [19]. Although other factors (for example parafunctional activity, bone condition, and implant axis inclination) might also be of crucial importance, valid evaluation was not possible, because the study design was based on the records. Once osseointegration has taken place, loading forces seem to be uncritical: No late implant losses were observed in this study—neither with RDPs in the maxilla nor with complete dentures. This is in accordance with Jofré et al., who found no effect of patient bite force on marginal bone loss and, thus, on long-term implant success [19].

In the present study, no strict maintenance regime was administered. On the long-run, the lack of a consistent recall system might increase the risk of implant failure. Wennström et al. were able to demonstrate that regular supportive therapy is important for long-term implant success, especially in periodontitis-susceptible patients [20]. The lack of regular preventive maintenance seems to be significantly associated with peri-implantitis [21]. The implant failures observed in this study were early losses and not associated with peri-implant disease, even though patients were included with mid-term observation times of up to 7 years. However, as the mean observation time was 33 months only, it is possible that the results reported here might under-estimate the risk of implant failure due to peri-implantitis.

Only 2D panoramic X-rays were taken to assess the alveolar bone before operation. This has to be seen critically, especially in combination with flapless surgery. On the one hand, it has been established that survival and marginal bone loss of flapless implantation is comparable with the flap surgery approach [22]. On the other hand, Voulgarakis et al. reported bone perforation and implant misplacement to be frequently reported with flapless surgery [23], especially in large edentulous regions without anatomic landmarks for surgical reference. However, in their literature review they could not

identify an advantage of guided 3D navigation over free-hand flapless implantation regarding implant survival, marginal bone loss, or complications [23]. Despite this fact, it is possible that misplacing might have been a reason for some of the implant losses in the present study.

The performance of MDI used to support RDPs was poorer in comparison to those used with complete dentures. A significant difference was found between the groups—although these results must not be over-interpreted due to the small sample size. It can be speculated that stress on MDI to support cantilever RDP might be disproportionate. In the present study, MDI were placed in strategically beneficial positions. As a consequence, an increased number of MDI will be used in RDP cases in future. However, this issue must be addressed by additional investigations.

Our MDI survival results are in accordance with literature results. Griffitts et al. published results from a high-quality prospective investigation of 30 edentulous patients [24]. They placed 116 MDI with diameters of 1.8 mm and lengths between 10 and 18 mm in the anterior mandible. After 5.5 months implant survival was 97.4%. Shatkin et al. conducted an investigation on 2514 Implants in 531 patients [25]. Implants were placed in mandible and maxilla to support removable and fixed dentures. Overall implant survival after a mean period of three years was 94.2%. Mundt et al. conducted a practice-based study in nine dental offices with 133 patients [9]. After up to 61 months, 11 of 402 mandibular MDI were removed. Four mandibular implants fractured. Four-year survival was 95.7% for the mandible. Taken together, the results of our analysis were in agreement with the good survival reported in literature.

Prosthetic aspects of MDI treatment have, so far, been largely neglected in literature. In agreement with the results of this study, Mundt et al. found all of 144 overdentures to be still functioning after four years. Typical maintenance intervention was repair of denture base fractures (incidence 20%, this study 24%), relining, and change of plastic rings. Integration of a metal framework in the patients' dentures might reduce the incidence of fractures and should be considered, at least when this complication occurs. Previously existing frameworks, on the other hand, might interfere with integration of the metal housings and might have to be partially removed. This might subsequently reduce the stability of the denture to an unknown extent. In the study of Mundt et al., no prosthetic aftercare throughout the observation time was required for 57.9% of the participants. Prosthetic intervention was required more than once for 30% of the patients. In this study, the incidence of relining was rather high (56%). However, the majority of these relining sessions were single events that had been scheduled before implantation and must be interpreted not as a complication but as a part of the treatment concept. Implantation leads to bone level changes and alterations in the peri-implant soft tissues. Relining is necessary to optimize denture fit and to refine the acrylic denture base after chairside integration of the housings. After a mean observation time of 33 months, 16% of the dentures needed additional relining. The literature on regular implant-retained overdentures indicates that relining and fractures are the usual maintenance procedures [26,27]. Attard and Zarb reported laboratory relining to be necessary every 4 years for overdentures retained by regular implants [28]. However, it is difficult to summarize the incidence of prosthetic complications with regular implant overdentures as the incidence tends to vary depending the study design [29]. Nevertheless, it can be concluded that maintenance for MDI-retained overdentures must not be under-estimated. Relining is among the most frequent complications [30]. Other typical complications are damage of rings, denture relining, worn teeth, detachment of the metal housings, and fracture of mandibular overdentures [30].

MDI treatment might successfully address relevant problems of elderly denture wearers with low income or fear of dental surgery [7]. Within mid-term periods of observation, MDI treatment seems to be cost-effective and successful, although aftercare should not be under-estimated. Griffitts et al. reported that the cost of four MDI was equivalent to that of one conventional implant [24]; the reason for the low cost of MDI in comparison with standard diameter implants was unknown [6]. The MDI concept seems applicable for a wide range of mandibles, with augmentation procedures often being avoided. Basic objectives, for example enhanced denture stability, can be achieved. With MDI-retained overdentures, an oral health related quality of life can be achieved that was reported to be comparable with standard implants [31]. However, de Souza et al. found the survival rate of mini implants to be lower than that of regular implants when retaining mandibular overdentures [31]. Moreover, to achieve more elaborate objectives, for example rigid implant support, slender denture base design, and higher chewing efficiency, placement of four and more regular implants is preferable.

5. Conclusion

After mid-term periods of observation of up to seven years, survival of MDI placed in the mandible was acceptable if the opposing maxilla was restored with a complete denture. Complications, for example denture base fracture and relining, must not, however, be under-estimated.

Conflict of interest

No conflicts of interest declared.

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