Implant-Supported Mandibular Overdentures Retained with a Milled Bar: A Retrospective Study

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Purpose: *The aim of this retrospective study was to evaluate implant survival rate, peri-implant conditions, and prosthodontic maintenance for implant-supported mandibular overdentures rigidly retained with a milled bar.* ***Materials and Methods:*** *Patients with 4 interforaminal implants (cylindric or screw-type) supporting an overdenture on a milled bar treated between 1996 and 2004 were asked to participate in a retrospective study. The cumulative implant survival rate and peri-implant conditions (marginal bone loss, pocket depth, Plaque Index, Gingival Index, Bleeding Index, and calculus presence) were evaluated and compared between cylindric and screw-type implants. The incidence and type of prosthodontic maintenance and subjective patient satisfaction rating were also evaluated.* ***Results:*** *Fifty-eight of 67 patients (87.3%) and 232 implants (76 cylindric, 156 screw-type) were available for follow-up examination after a mean period of 59.2 ± 26.9 months. The cumulative implant survival rate was 99%, and no differences in peri-implant soft tissue conditions were noted between the different implant types used. The cylindric implants showed more pronounced marginal bone resorption than the screw-type implants (1.9 ± 0.6 mm vs 2.2 ± 0.6 mm;* P *= .02) but the difference was not clinically significant. A low incidence of prosthodontic maintenance evenly distributed throughout the overall follow-up period and a high subjective satisfaction rating by the patients were noted.* ***Conclusion:*** *Interforaminal screw-type and cylindric implants supporting a milled bar for rigid overdenture anchorage were associated with a high survival rate and excellent peri-implant conditions. The incidence of prosthodontic maintenance was low and evenly distributed throughout the follow-up period as a result of rigid denture stabilization by the milled bar. Rigid anchorage of a mandibular overdenture with a milled bar unites the prosthodontic advantages of removable and fixed prostheses.* (Clinical Trial) (More than 50 references.) INT J ORAL MAXILLOFAC IMPLANTS 2007;22:987–994

Key words: *edentulous mandible, implant-supported overdentures, milled bar, prosthodontic maintenance*

Dental implants have been successfully used in the treatment of edentulous mandibles for more than 3 decades.[1–9] Implant prosthodontic treatment alternatives for oral rehabilitation of edentulous mandibles include *(1)* fixed but detachable prostheses,[1–5] *(2)* implant-retained mucosa-supported overdentures,[6–11] and *(3)* implant-supported overdentures (ie, supported solely by implants).[12–14]

Implant-retained mucosa-supported overdentures and fixed prostheses have demonstrated 5-year implant survival rates of 94% to 100% and the highest rates of patient satisfaction.[1–3,6–11,15–17] Abutment types commonly used to anchor implant-retained overdentures include bars of different designs, balls, and magnetic attachments.[17–19] No consistent differences are reported in patient satisfaction rates with respect to the attachment type used with mucosa-supported implant-retained overdentures or with respect to the use of splinted and unsplinted retention modalities.[18–23] However, although ball-supported overdentures have been given preference over single attachments (eg, magnetics),[17] MacEntee et al and Payne and Solomons, in separate studies, demonstrated that single ball attachments require significantly more postoperative care during the follow-up period than splinted bar constructions.[20,23]

Round bars or Dolder bars are the predominant styles of bars used to connect 2 or 4 implants.[8–10,20–25] Although no clinical differences in patient satisfaction or implant survival rate have been demonstrated between round bars connecting 2 implant and round

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bars connecting 4 implants,[22–25] the frequency of prosthodontic maintenance for implant-supported overdentures is an area of controversy.[20,23,24] In a recent study by Visser et al,[24] no differences were found between the use of 2 implants versus that of 4 implants for prosthodontic maintenance of overdentures connected with round bars. In contrast, Payne and Solomons[22] described more postplacement maintenance with multiple round-bar connections than with 2 implants connected by round bars. In addition, when fixed prostheses were compared with the 2-implant mucosa-supported overdentures, pronounced residual ridge resorption was observed in the load-bearing mucosal regions as compared with the same regions in patients with fixed prostheses.[26,27]

To both of the aforementioned treatment modalities, the overdenture rigidly anchored on a milled bar may be an alternative. A milled bar supported by 4 interforaminal implants prevents rotational movement of the prosthesis.[28,29] As with a fixed prosthesis, rigid anchoring of an overdenture reduces possible jaw resorption and consequently may also reduce the incidence of prosthodontic maintenance. Therefore, the use of a milled bar for a purely implant-supported mandibular overdenture may be considered for clinical advantages similar to those of a fixed prosthesis[1–4,26,27] and, possibly, the prosthodontic advantages of the removable denture.[1–3,9–11,15] Because traditional treatment regimens invariably only consider the 2-implant–retained mucosa-supported overdenture and the implant-supported fixed prosthesis, literature on the use of a milled bar supporting a rigidly stabilized removable overdenture is very limited.[12–14,28,29]

The aim of this retrospective study was to report the clinical implant survival rate and peri-implant conditions of purely implant-supported mandibular overdentures using a milled bar architecture. In addition, special interest was focused on the incidence and types of prosthodontic maintenance encountered for this retention modality.

MATERIALS AND METHODS

Patient and Implant Distribution

Patients who received 4 submerged interforaminal implants between March 1996 and June 2004 for implant-based prosthodontic rehabilitation were recruited for this retrospective clinical follow-up study. The implants placed interforaminally were either cylindric (IMZ; Friadent, Mannheim, Germany), or screw-type (Frialoc [Friadent] or Camlog root-line [Alltec, Wurmberg, Germany]). Surgery was performed as recommended by the manufacturer. After a healing period of 3 months, the implants were uncovered, healing abutments were inserted, and prosthodontic procedures were started. All participants gave their informed consent for the study.

Prosthetic Treatment

For all patients the splinting suprastructure for 4 implants consisted of a milled bar of either titanium (Rematitan, Dentaurum, Germany) or a gold alloy (Stabilor NF IV, Ögussa, Austria) cantilevered posteriorly. The maximal length of bar cantilevering was calculated in relation to the planned prostheses. The maximal prosthodontic cantilever length (ie, the most posterior occlusal surface, was no more than 1.5 times the anteroposterior distance between the mesial and distal implants).[30] The length of the bar extension was such that the region of the second premolar (or the mesial part of the first molar) was always within the defined dimension.[30,31] All overdentures were reinforced by a cast framework and consisted of 12 acrylic resin teeth. The milled-bar architecture had a tapered design (2 to 4 degrees) and included retention devices. As an additional retention device Preci Vertex (Alphadent, Antwerpen, Belgium) was used in the posterior bar extensions and Variosoft (Bredent, Senden, Germany) was used in the splinted anterior region (between the anterior implants). An example of the milled bar used in this study is shown in Fig 1. An overdenture base with the metal-reinforced framework can be seen in Fig 2.

Follow-up Examination

Patients were called for a follow-up examination. For the most recent follow-up, implant survival rate and peri-implant conditions, as well as patients' subjective assessment of the implant-supported overdenture, were evaluated. Examination of the peri-implant conditions included evaluation of peri-implant marginal bone loss (mm) and probing (pocket) depth (mm), as well as Plaque Index, Bleeding Index, Gingival Index, and presence of calculus. Plaque and Bleeding Indices were assessed according to Mombelli et al[32]; a score of 0 to 3 was given. For assessing potential peri-implant inflammation, the Gingival Index (the modified Löe and Silness Index [33]) was used; a score of 0 to 3 was recorded. Probing (pocket) depth was defined as a mean value of measurements at 4 sites (mesial, distal, lingual, buccal) using a calibrated periodontal probe (Hu-Friedy, Chicago, IL). The presence (score of 1) or absence (score of 0) of calculus was scored.

Peri-implant marginal bone loss (mm) was assessed radiographically using an orthopantomogram and/or single periapical radiographs based on the paralleling technique.[34,35] The distance between

Fig 1 Milled mandibular bar with posteriorly cantilevered extensions, including retention devices.

Fig 2 Overdenture base with a metal-reinforced framework.

the crestal bone level and a reference point on the implant (lateral border of the implant platform) was measured for each implant on radiographs obtained at baseline (implant placement) and at the most recent follow-up examination.[24,34–38] Data for patients with cylindric implants were compared with data for patients with screw-type implants.

Postinsertion Maintenance and Patient Assessment

During the follow-up period prosthodontic complications and repairs for *(1)* the implant-supported overdentures (ISO) group and *(2)* the opposing dentition (OD; partial, complete, or implant-supported prostheses) were registered and calculated[22] as follows:

1. Implant component maintenance: implant loss/fracture, abutment screw loosening, abutment/bar fracture
2. Prosthesis component maintenance for ISO and OD: matrix activation/renewal (Preci Vertex or Variosoft), fracture or adjustment of overdenture teeth, overdenture fracture, denture margin adaptation (reduction or relining), overdenture rebase, and maintenance of the opposing prosthesis.

Overall subjective patient satisfaction with implant-supported overdentures was assessed by questionnaire (modified according to MacEntee et al[20]) at the recall examination. Patients were asked whether several aspects of their care were *(1)* not satisfactory, *(2)* adequate, *(3)* satisfactory, *(4)* good, or *(5)* excellent. Questionnaires were provided for general satisfaction, chewing ability, denture stabilization, speech, and esthetics.

Statistical Analysis

The parameters were recorded, tabulated, and evaluated. A life table was constructed to generate the cumulative survival rates for the implants. Categoric variables for nonparametric data were compared using the χ^2 test, and mean values were tested with the Student *t* test. For all statistical analyses, Stat View 5.0 (SAS Institute, Cary, NC) was used. $P < .05$ was considered the level of statistical significance.

RESULTS

Of the 67 patients, 58 (32 female, 26 male; mean age: 65.7 ± 7.2 years) were available for the follow-up investigation. Seven patients were not available for the follow-up examination because they had died (n = 2) or moved away from the region (n = 5); 2 patients could not be followed for unknown reasons (dropout rate: 9/67 or 13.4%). Thus, the results presented are based on 58 patients with 232 implants. For the patients (n = 58) included in the follow-up study, the opposing maxillary dentition consisted of implant-supported complete dentures (n = 43), partial anterior dentition with posterior partial dentures (n = 7), natural teeth (n = 2), or implant-supported overdentures (n = 6).

The number of patients by implant type is described in Table 1. Two initially placed cylindric implants (IMZ; Friadent; length, 15 mm; diameter, 4.0 mm) were prematurely lost during the osseointegration period. They were replaced by new implants after bone consolidation and used for the initially proposed prosthodontic procedure. The follow-up period varied between 12 and 118 months, with a mean value of 59.2 ± 26.9 months. The follow-up period of the cylindric implants (89.5 ± 15.6 months, range: 71 to 118 months) was significantly longer than that for the screw-type implants (42.3 ± 15.6 months; range: 12 to 66 months; $P < .01$).

No implants were lost during the follow-up period; thus, the overall cumulative survival rate was

Table 1 Description of Implants and Patients

Manufacturer (location)	No. of implants	Implant size (mm) L	Implant size (mm) D	No. of patients M	No. of patients F	Patient age (y) Mean	Patient age (y) SD
Cylindric							
IMZ (Friadent, Mannheim, Germany)	76	13 or 15	3.3 or 4	10	9	67.2	7.2
Screw-type							
Frialoc (Friadent)	16	15	3.8	2	2	64.8	8.1
Camlog (Alltec, Wurmberg, Germany)	140	11, 13, or 16	3.8 or 4.3	21	14	65.7	6.1

L = length, D = diameter, M = male, F = female.

Table 2 Life Table Analysis

	Total				Cylindric				Screw-type			
	No. of implants	Failed	Censored	CSR (%)	No. of implants	Failed	Censored	CSR (%)	No. of implants	Failed	Censored	CSR (%)
Placement to loading	234	2	0	100	78	2	0	97.4	156	0	0	100
Loading to 1 y	232	0	0	99.1	76	0	0	97.4	156	0	0	100
1 to 2 y	196	0	36	99.1	76	0	0	97.4	120	0	36	100
2 to 3 y	160	0	28	99.1	76	0	4	97.4	84	0	24	100
3 to 4 y	132	0	36	99.1	72	0	12	97.4	60	0	24	100
4 to 5 y	96	0	44	99.1	60	0	20	97.4	36	0	24	100
> 5 y	52	0	0	99.1	40	0	0	97.4	12	0	0	100

CSR = cumulative survival rate.

Table 3 Peri-implant Bone Resorption, Pocket Depth, and Soft Tissue Conditions of the Followed Implants

	Total		Cylindric		Screw-type	
	Mean	SD	Mean	SD	Mean	SD
Bone loss	2.1	0.7	2.2*	0.6	1.9*	0.6
Mesial	2.2	0.7	2.3†	0.5	2.0	0.5
Distal	2.0	0.6	2.0†	0.5	1.9	0.6
Probing depth (mm)	3.6	1.8	3.3	2.0	3.2	1.8
Plaque Index (0 to 3)	0.6	0.5	0.6	0.6	0.6	0.7
Gingival Index (0 to 3)	0.3	0.4	0.3	0.5	0.3	0.5
Bleeding Index (0 to 3)	0.4	0.5	0.5	0.5	0.6	0.5
Calculus presence (0 or 1)	0.6	0.3	0.3	0.4	0.2	0.4

*P = .024.
†P = .012.

99% (97.4% for cylindric versus 100% for screw-type; Table 2). Peri-implant findings have been summarized in Table 3. The data evaluated for soft tissue conditions showed no differences between screw-type and cylindric implants. Peri-implant marginal bone showed a higher degree of bone loss for cylindric implants than for screw-type implants (2.2 ± 0.6 mm vs 1.9 ± 0.6 mm; t = 2.294, P = .024). Moreover, for cylindric implants, a significant difference (t = 2.627, P = .012) of marginal bone loss between mesial and distal implants (2.3 ± 0.5 mm vs 2.0 ± 0.5 mm) was noted. Screw-type implants showed no significant difference of bone loss between mesial and distal implants (2.0 ± 0.5 mm vs 1.9 ± 0.6 mm; Table 3).

During the follow-up period, a total of 51 prosthodontic maintenance procedures were required. There were 32 interventions for 58 mandibular ISO and 19 interventions for 56 opposing prostheses (Table 4a). Implant component maintenance included abutment screw loosening (6 cylindric implants and 2 screw-type implants, without any predominance of location), but no implant, abutment, or bar fractures occurred. The most common postinsertion prosthodontic maintenance procedures required for the ISO group were modifications of the prosthesis margin (reductions and additions by relining; 9 cases) or rebasing (5 cases). The most common postinsertion prosthodontic maintenance procedure required in

Table 4a Prosthodontic Maintenance and Complications: ISO and OD

	Incidence
ISO	
Implant component maintenance	
Abutment screw loosening	8
Prosthodontic maintenance	
Matrix activation/renewal	6
Prosthetic teeth fracture or adjustment	4
Denture margin adaptation (reduction or relining)	9
Overdenture rebase	5
OD	
Prosthodontic maintenance	
Prosthetic teeth fracture	5
Denture rebase	11
Denture renewal	3
Total	51

ISO = implant-supported overdentures; OD = opposing dentition.

Table 4b Prosthodontic Maintenance (Incidence) of ISO (n = 58) and OD (n = 56) During the Follow-up Period

	ISO		OD		Total maintenance	
	n	%	n	%	n	%
0 to 1 y	7/58	12.0	3/56	5.4	10/114	8.8
1 to 2 y	6/49	12.2	4/47	8.5	10/96	10.4
2 to 3 y	6/40	15.0	3/39	7.7	9/79	11.4
3 to 4 y	5/33	15.1	3/32	9.4	8/65	12.3
4 to 5 y	3/24	12.5	2/23	8.7	5/47	10.6
5 to 9 y*	5/13	12.8	4/12	8.3	9/25	12.0

*4-year summation due to small number of ISO and OD followed during this period.

the OD group was denture rebasing (11 cases). Maintenance of the integrated retention elements (acrylic clip activation or renewal) was required in 6 cases. Table 4b shows the incidence of interventions in relation to the time of use of the restoration. The overall incidence of prosthodontic maintenance per year for ISO and OD ranged from 5% to 15% (Table 4b).

A high subjective satisfaction rate was reported at the follow-up examination for the ISO group (Fig 3). Mean scores (± SD) were 4.8 ± 0.2 for general satisfaction, 4.6 ± 0.3 for chewing ability, 5.0 for denture stability, 4.7 ± 0.2 for speech, and 4.3 ± 0.3 for esthetic results (Fig 3).

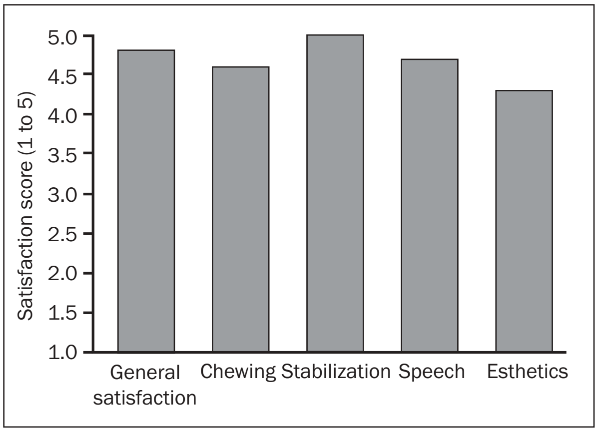

Fig 3 ISO patients' subjective satisfaction scores.

DISCUSSION

This retrospective follow-up study showed a high implant survival rate and a high degree of patient satisfaction for patients with edentulous mandibles treated with overdentures rigidly anchored on a distally cantilevered milled bar. The cumulative 5-year implant survival rate (99%) and the results for peri-implant soft tissue conditions were independent of the implants used and were similar to those reported in other studies investigating either fixed or removable prostheses in edentulous mandibles.[1–9] According to success criteria[39,40] that do not use individual annual measurements of crestal bone as an essential criteria for success[2] but rather absence of peri-implant radiolucency on radiographs, the present findings of implant survival rate and peri-implant parameters suggest that the implant success rate could also be considered high.

After a mean observation period of 59.2 months, an overall marginal bone resorption of 2.1 mm was noticed without any influence on implants, peri-implants soft tissue, or prosthodontic outcome. The distal cantilevering of the milled bar, including the overlying prosthesis, was within the dimensions recommended by McAlarney and Stavropoulos[30] and had no negative influence on the marginal implant bone resorption and implant survival rate. However, the cylindric implants in general and the cylindric implants placed in the anterior region in particular were associated with more marginal bone loss than screw-type implants. This difference in bone loss between screw-type and cylindric implants were relatively minor and may be explained by the longer observation period for the cylindric implants.[34,35,41–43] Moreover, bending moments or a thin circumferential bone wall in the mandibular anterior region may be considered as potential causative risk factors for the bone loss.[42–44] Implant characteristics and their vertical dimension of implant shoulder placement may have also contributed to bone preservation; there may have been a difference between crestally placed cylindric implants and supracrestally placed screw-type implants.[4,44–46] The overall favorable course of the implants (in spite of their different characteristics) and the prostheses in this study may have been influenced by the use of load sharing theory to reduce potential stress-induced microdamage. This theory can be applied when using a rigid anchoring system such as a milled bar with posterior support, as described by Mericske-Stern et al[47] and McCartney.[48]

Reports of prosthodontic maintenance of implant-supported mandibular overdentures contain little information on prosthodontic aftercare of overdentures anchored on 4 interforaminal implants.[22–25] Only a few comparative prospective studies have demonstrated that overdentures anchored on multiple round bars on 3 or 4 implants have fewer clip activation needs but more clip fractures than overdentures retained on the standard 2-implant bars.[22,24,25] As a limitation of these studies it must be pointed out that the overdentures in these reports were retained on round bars without distal extension, which creates a mucosa- and implant-supported denture functioning as a hinging overdenture with more than 1 axis of rotation.[22–25]

A notable result of the present study was that the overdentures rigidly anchored on 4 interforaminal implants with milled bars demonstrated a low incidence rate of prosthodontic maintenance requirements throughout the observation period. The present findings confirmed the hypothesis of Payne and Solomons[22] that additional distal support may create a more stable overdenture. The results obtained are also consistent with findings of Dudic and Mericske-Stern,[49] who also demonstrated that rigid overdenture stabilization on 4 implants is associated with fewer prosthodontic complications than a resilient anchorage system. For instance, in separate studies, Payne and Solomons[22] and Hemmings et al,[50] found frequent prosthodontic maintenance for overdenture rebasing when using resilient anchoring systems. In contrast, the incidence of overdenture rebasing in the present study was markedly reduced.[11–13] The low incidence of prosthodontic maintenance may be due to the milled-bar architecture, which is responsible for reduced rotational movement in comparison with the resilient mucosa-supported overdentures. Milled bars provide for primary retention along the path of insertion and reduce rotational movement, which is favorable for preventing prosthodontic maintenance (clip activation) and jaw resorption.[12–14] The selected retention devices additionally improve the retention and can be activated when clinicians or patients determine loss of retention between the milled bar and the metal-reinforced denture base.

In light of these findings it could be hypothesized that not only the number of implants but more evidently the kind of anchoring system (bar design) used (ie, a round or parallel milled-bar design) and thus the rigidity/resilience of the stabilization may affect prosthodontic outcome.[14,47]

Another interesting finding of the present study was that the low incidence of prosthodontic aftercare interventions was evenly distributed throughout the follow-up period. This is in obvious contrast to reports in the literature on the maintenance requirements for conventional implant- and mucosa-retained resilient overdentures describing an increased percentage of maintenance procedures during the first years of use.[20–23,50] Thus, according to these findings with 4 interforaminal implants placed to support a mandibular overdenture, the use of a pure implant support with a milled bar for rigid stabilization can be recommended rather than the use of a resilient anchoring system.[49,50]

In cases with advanced atrophy and with unfavorable maxillomandibular relations, fixed prostheses lead to deterioration with regard to facial appearance because of lack of facial support.[51] Soft tissue support by prosthetic margins and prosthetic posts is necessary to ensure adequate cosmetic results.[49,52] In such cases the use of the milled bar for anchoring mandibular overdentures combines the favorable features of removable and fixed prostheses.[1,4,11,12] Denture stability and retention is similar to that of a fixed prosthesis and resorption in the mandibular posterior and maxillary anterior region is prevented because of the stability of the occlusal plane.[26,27] In addition, the flanges of the overdenture may be utilized to compensate for esthetic and vertical disharmony and to facilitate handling and cleaning.[6–11]

Consideration of the production costs of the implant-prosthetic solution such as the one described in the present study should be balanced with recognition of their lower maintenance and repair costs, especially considering their long-term stability.[53–55] Thus, the use of milled bars for the anchorage of an implant-supported rigid overdenture provides clinical benefits which justify its consideration as a viable treatment option in the edentulous mandible.

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CONCLUSION

On the basis of this retrospective clinical review the following was observed:

1. Four interforaminal implants supporting a milled bar for rigid overdenture anchorage was associated with a high implant survival rate and satisfactory peri-implant soft tissue conditions.
2. The use of a milled bar with a defined cantilever length and rigid overdenture stabilization had no negative influence on the marginal implant bone resorption and consequently on implant and prosthodontic outcomes.
3. The prevention of denture rotation and a low incidence of prosthodontic maintenance, evenly distributed throughout the follow-up period, may be attributed to the rigid stabilization provided by the milled bar.

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