The Influence of Bar Design (Round Versus Milled Bar) on Prosthodontic Maintenance of Mandibular Overdentures Supported by 4 Implants: A 5-Year Prospective Study

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Purpose*:** The aim of the present study was to evaluate the prosthodontic maintenance required for mandibular overdentures supported by 4 implants and splinted with either a round bar and resilient overdenture anchorage or a milled bar with rigid anchorage over a 5-year period. ***Materials and Methods*:** In a randomized prospective trial, 51 edentulous patients received 4 mandibular interforaminal implants to support an overdenture and maxillary complete dentures. For the implant-supported overdentures (IODs), bar architecture and denture stabilization were chosen randomly; 25 patients received round bars (group 1) and resilient anchorage and 26 patients received milled bars (group 2) and rigid anchorage. The prosthodontic maintenance required for the IODs and opposing dentures were evaluated during a 5-year follow-up period and compared between the 2 retention modalities used for IODs. ***Results*:** Forty-six patients (22 in group 1, 24 in group 2) were available for a 5-year follow-up (dropout rate: 9.8%). Prosthodontic maintenance efforts were significantly greater ($P < .01$) with the round bar design (group 1) than with the overdentures stabilized with milled bars (group 2). In group 1, prosthodontic maintenance efforts were more frequent in the early phase of use (1 to 2 years), as compared with an evenly distributed incidence over the 5-year period with the rigid milled bar system. Major prosthetic complications (IOD remaking, bar fracture) were only seen in cases without metal-reinforced frameworks (group 1). ***Conclusion: When 4 interforaminal implants are used to anchor mandibular overdentures, the design of the anchorage system will significantly affect prosthodontic maintenance efforts and complication rates. Rigid anchorage using milled bars and a metal-reinforced denture framework required less prosthodontic maintenance, ie, for clip activation/fracture, than resilient denture stabilization using multiple round bars without a rigid denture framework. *Int J Prosthodont 2008;21:514–520.*

The prosthodontic maintenance required for mandibular implant-supported overdentures (IODs) has considerable clinical, laboratory, and economic implications.[1–5] Detailed knowledge of the expected amount of postinsertion maintenance affects not only prosthodontic success but also clinician and patient satisfaction, as well as costs.[1,2,6–12]

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Numerous prospective and retrospective studies have investigated the prosthodontic maintenance efforts required for splinted and unsplinted interforaminal implants supporting overdentures, most of which used a round bar or sliding attachment mechanism.[1,2,6–11] In most studies, bar stabilization of IODs supported by 2 or 4 implants typically employs round or Dolder bar architecture.[5–11] Although round bars connecting 2 or 4 implants demonstrated no clinical differences in patient satisfaction and implant survival rates, the frequency of prosthodontic maintenance for IODs has been a source of controversy.[2,12] Visser et al[12] recently found no differences for overdenture prosthodontic maintenance between 2 or 4 implants connected with round bars, and Payne and Solomons[2] found that more postplacement maintenance was needed for multiple round bar connections than for round bars connecting 2 implants.

In contrast to mucosa-supported resilient treatment modalities employing round bars, an overdenture that is rigidly anchored to a milled bar supported by 4 interforaminal implants prevents rotational movement of the prosthesis.[13–16] Thus, similar to a fixed prosthesis, rigid anchorage of the overdenture reduces possible jaw resorption and consequently may also reduce the incidence of prosthodontic maintenance.[16–19] Therefore, the use of a milled bar for a pure IOD in the mandible may be considered as a viable treatment option for patients who require clinical advantages similar to those of a fixed prosthesis but require the prosthodontic advantages of a removable denture.[16,20] However, because traditional treatment regimens invariably only consider the 2-implant–retained, mucosa-supported overdenture[8–11,21] or a fixed prosthesis supported by several implants,[1–5] literature on the use of a milled bar supporting a rigidly stabilized removable overdenture is very limited.[14–16]

There are few studies comparing the prosthodontic maintenance efforts required for 2- or 4-implant overdentures splinted with round bars and any advantages or disadvantages associated with the use of 4 implants.[2–4,12] In all of these studies the number of implants and their connections, especially including the classical resilient (round) bar design, was the topic of investigation and the results varied.[2,12] There is no sophisticated comparison of the effects of several different anchorage systems on the postinsertion course of IODs supported by 4 interforaminal implants.

The objective of this prospective study was to evaluate the prosthodontic maintenance efforts of IODs supported by 4 implants rigidly anchored by a milled bar versus an IOD anchored by traditional round bar attachments over a 5-year period. The null hypothesis of the study was that there would be no differences in prosthodontic postinsertion maintenance between rigid and resilient anchorage systems.

Materials and Methods

Patient Selection and Treatment

Charts of 51 consecutive participants (28 women, 23 men; mean age: 59.6 ± 8.3 y) with edentulous mandibles (Cawood Class III to V) and complete maxillary dentures were included in the study. Between March 1997 and February 2000, the included patients (n = 51) received 4 interforaminal implants in the mandible to anchor an IOD and new maxillary complete dentures. The implants were placed interforaminally and were either cylindric (IMZ, Friadent) or screw shaped (Frialoc, Friadent; Camlog root-line, Alltec). After standardized implant placement and a healing period of 3 months, the implants were uncovered and healing abutments were inserted. For prosthodontic rehabilitation, definitive abutments were inserted and the patients were randomly selected to receive IODs retained with 1 of the 2 prosthodontic treatments (rigid anchorage with a milled bar or traditional round bar attachments). Each patient was given a detailed description of the procedures and signed an informed consent prior to participation. The study protocol was approved by the local ethics committee.

Prosthodontic Treatment

Two different prosthodontic designs were used for the mandibular IODs, and the patients were randomly assigned to 2 different groups.

Group 1 (resilient design). Twenty-five patients (16 women, 9 men, mean age: 61.1 ± 7.6 y) received a resilient anchorage system. This consisted of a 3-mm round (ovoid) bar splinted on standard abutments connected to 4 interforaminal implants (88 IMZ, 12 Frialoc; length 13 or 15 mm, diameter 3.3 or 4 mm). The round bar was soldered using prefabricated bars with 3-mm designs. Three individual retention clips were situated on the bar (titanium/gold alloy). One retention clip was located in the anterior bar region (between both anterior implants), and 2 more clips (1 on each side) were made in the posterior bar regions. Posterior retention clips were constructed to fit either between the lateral implants or in the distal bar extension (when the interimplant distance of the lateral implants was too short). Figure 1a shows an example of the round (ovoid) bar used in this study following standardized techniques. All group 1 dentures were made without a metal-reinforced framework in a similar fashion as described in previous studies (Fig 1b).

Group 2 (rigid design). Twenty-six patients (12 women, 14 men, mean age: 58.2 ± 9.5 y) received a rigid anchorage system that splinted the 4 interforaminal implants (104 Camlog root-line; length 11, 13, or 16 mm; diameter 3.8 or 4.3 mm) with a suprastructure consisting of a milled bar with a 2- to 4-degree tapered design (titanium/gold alloy) with a retention device for metal-reinforced overdentures. The milled (titanium laser welded/gold alloy cast) bar was cantilevered posteriorly with no more than 1.5 times the anteroposterior distance between the mesial and distal implants.[22] As additional retention devices, Preci Vertex (Alphadent) attachments were used in the posterior bar extensions and Variosoft (Bredent) attachments were used in the splinted anterior bar region (between both anterior implants). Figure 2a shows an example of the milled bar used in this study. Figure 2b shows the overdenture base with the metal-reinforced framework.

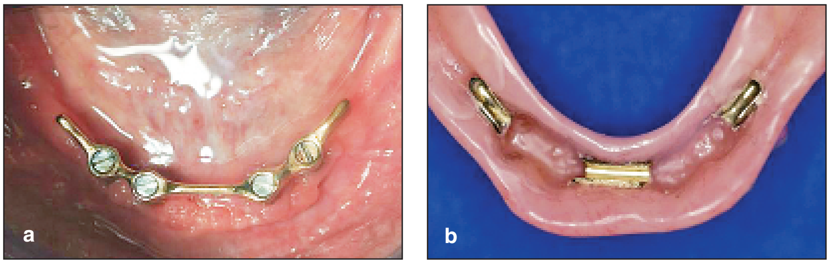

Fig 1a Implants splinted with round (ovoid) bar including retention devices.

Fig 1b Traditional prosthesis with 3 clips for anchoring IOD.

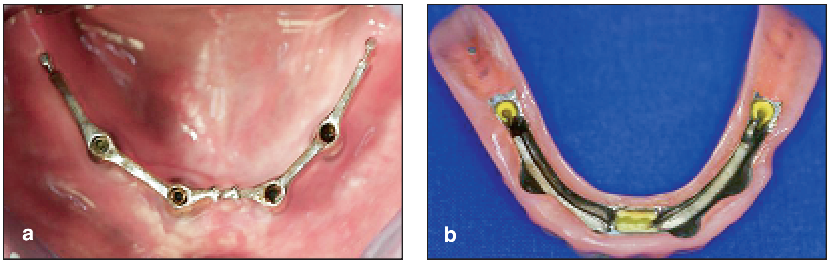

Fig 2a Milled mandibular bar with posterior cantilever extensions including retention devices.

Fig 2b Overdenture base with the metal-reinforced framework.

Table 1 Characteristics of the Patients Studied

	Group 1	Group 2
n	25	26
Age (y)	61.1 ± 7.6	58.2 ± 9.5
Gender (f/m)	16/9	12/14
Mean edentulous period mandible (y)	4.9 ± 4.8	5.2 ± 6.1
Mean mandibular bone height (mm)	15.1 ± 3.2	16.1 ± 3.8
Mean implant length (mm and range)	13.6 (13–15)	13.9 (13–16)

Group 1 = round resilient bars; Group 2 = rigidly splinted milled bars.

Postinsertion Maintenance and Patient Assessment

For all participants (n = 51), follow-up visits were part of a regular recall program and were scheduled initially as control visits (during the first 3 months) and thereafter as annual recall visits. Recalls were not always regularly attended by all patients. Any additional visits were initiated by the patients if they experienced problems. During the follow-up period, implant survival rates were calculated and prosthodontic complications/repairs for the IODs as well as for the maxillary complete dentures were recorded (modified from Payne and Solomons,[2] Hug et al,[23] and Kiener et al[24]) according to the following events:

1. Implant component maintenance: implant loss/fracture, abutment screw loosening, abutment/bar fracture, implant/bar hygiene complications.
2. Prosthesis component maintenance for IOD and complete denture: matrix activation/renewed (Preci Vertex or Variosoft), overdenture teeth fracture/renewed, overdenture fracture, denture margin adaptation (reduction or relining), overdenture rebased, and opposing complete denture maintenance (fracture/rebased/remade).

The prevalence of prosthodontic maintenance efforts or complications was compared between the resilient (group 1) and the rigid (group 2) anchorage systems.

Statistical Analysis

The parameters were recorded, tabulated, and evaluated. A life table was constructed to generate cumulative survival rates for the implants. Categorical variables for nonparametric data were compared using the chi-square test, and mean values were tested using the Student *t* test. Stat View 5.0 (SAS Institute) was used for all statistical analyses. $P < .05$ was taken as the level of statistical significance.

Results

From the original group of 51 patients included in this prospective study, 46 patients with IODs and new maxillary complete dentures were monitored for up to 5 years. All patients presented for implant uncovering (n = 51), but thereafter several dropouts in both prosthodontic designs were noted for annual recall examinations. The incidence of dropouts (9.8%) did not vary between the groups and was a result of patient illness (stroke, cancer) or death or individual reasons (moving away from the region, not interested in follow-up). Interestingly, the dropout rate decreased for the last examination (5 years) because patients were carefully admitted for the recall examination for the present study. Thus, it was assumed that failure to present for the follow-up was independent of clinical status. Table 1 provides the patient characteristics in this prospective study.

Table 2 Type of Prosthodontic Maintenance and Complications in Mandibular IODs and Maxillary Complete Dentures (CDs) Retained by Milled Bars (MB) or Resilient Round Bars (RB)

	1 y		2 y		3 y		4 y		5 y		Total	
	RB (n = 25)	MB (n =26)	RB (n =24)	MB (n =26)	RB (n = 22)	MB (n = 23)	RB (n = 21)	MB (n = 22)	RB (n = 22)	MB (n = 24)	RB	MB
Implant component maintenance												
Implant fracture	0	0	0	0	0	0	0	0	0	0	0	0
Abutment screw loosening	4	2	4	0	2	0	2	4	2	0	14	6
Abutment fracture	0	0	0	0	0	0	0	0	0	0	0	0
Implant bar fracture	0	0	0	0	2	0	0	0	1	0	3	0
IOD maintenance												
Matrix activation/ renewal	9	0	8	2	6	2	3	2	3	2	29	8
Prosthesis teeth fracture/renewal	1	0	0	1	2	1	1	1	2	1	6	4
Overdenture fracture	2	0	1	0	1	0	2	0	1	0	7	0
Denture margin adaptation (reduced/relined)	8	2	6	3	3	0	2	0	4	2	23	7
Overdenture rebased	3	0	4	0	1	1	3	2	3	0	14	3
CD maintenance												
Denture teeth fracture (renewed)	1	1	1	3	2	0	2	0	1	1	7	5
Denture rebased	4	1	7	2	6	1	4	3	4	2	25	9
Denture renewed	0	0	0	0	1	2	1	0	2	1	4	3
Total	32	6	31	11	26	7	20	12	23	9	132	45

For the 46 patients who were followed prospectively, the implant survival rate at the 5-year examination was 100% for both groups, without any differences between the 2 retention modalities used (round bar versus milled bar). There were also no differences in hygiene parameters between the bar designs, and gingival hyperplasia occurred in approximately 20% with both bar systems.

A wide variety of prosthodontic and technical complications and maintenance requirements were noted during this 5-year study (Table 2). Severe complications such as bar fracture (3 [2x cantilever]) and prosthesis fracture (7) occurred only in the round bar group (group 1) but not in the milled bar group (group 2). In general, the most frequent complication was activation or replacement of the retention devices in the prosthesis (n = 37) and adaptation of the denture margins (n = 30) with relining/reduction (Table 2). Significantly more matrix activation and repairs (29 versus 8; $P < .01$) and denture margin adaptations (23 versus 7; $P < .01$) were required in group 1.

In all, 132 maintenance procedures were required in group 1, and 45 interventions were needed in group 2 over the 5-year period. There was an annual mean of 1.2 complications/repairs for group 1 versus 0.3 interventions/repairs for group 2 ($P < .01$). For group 1 the prosthodontic interventions noted were concentrated during the first postinsertion years, which was in obvious contrast to group 2. Prosthodontic interventions in group 2 showed a homogenous distribution over the full observation period.

Discussion

The survival rate of implants in this prospective study was high in those patients taking part in the follow-up program and was comparable to the results of other prospective studies reporting excellent survival rates for implants supporting mandibular overdentures.[1,2,6–11] On account of the low dropout rate in both groups, a comparison between the 2 IOD anchorage systems could be established. The clinical results of implants and peri-implant structures seen in this study did not differ between the 2 prosthodontic anchorage systems and are consistent with those in other comparative studies, but they were not the focus of interest for the present investigation.[2,5–12,25]

Several reports have compared implant outcome and prosthodontic postinsertion maintenance of IODs using 2 or 4 implants with different attachments.[1–3,12] In 2 separate studies using a resilient round or Dolder bar attachment, Visser et al[12] and Payne and Solomons[2] compared implant and prosthodontic outcomes between IODs supported by 2 or 4 implants and reported no evident advantages for the use of 4 implants. Although the rotational movements may be limited by the use of more than 2 implants in an IOD with resilient design and with predominantly mucosal support, the number of implants did not show any beneficial influence on the incidence of prosthodontic maintenance or implant outcome.[2,12] Therefore, when resilient mucosa-supported overdentures are made, the traditional 2-implant treatment program can be selected as a favorable treatment regimen with regard to surgical, financial, and postinsertion aspects.[2,8–11,21,25]

However, in contrast to well-established clinical use and the large number of publications regarding hinged overdentures, milled bars with rigidly stabilized IODs have been used only rarely in clinical practice and for follow-up evaluation.[15,16] Few data exist comparing the use of resilient or rigid stabilization and investigating the effects of 4 interforaminal implants with regard to prosthodontic maintenance.[2,12,16,26]

The results of the present study demonstrate that 4 interforaminal implants rigidly retaining overdentures anchored with milled bars obviously result in a significantly lower incidence rate of prosthodontic maintenance than a resilient anchorage system with round bars. The low incidence of prosthodontic maintenance may be a result of the milled bar architecture providing for reduced rotational movements in comparison with the resilient mucosa-supported overdentures.[14–16] The results obtained are consistent with the findings of Dudic and Mericske-Stern[26] demonstrating that rigid overdenture stabilization on implants is associated with fewer prosthodontic complications than resilient anchorage. Results of milled mandibular bars with distal extensions from the anterior region[22] confirm the hypothetical statement of Payne and Solomon[2] that distal supports may provide for a more stable overdenture.[26,27] This may be a result of the implant-supported prosthesis design, which has a frictional overcasting that does not allow prosthesis rotation and thus reduces wear on the clips.[28–30] These observations are in accordance with the findings of Smedberg et al[29] and Zitzmann et al,[30] who used a similar bar design for overdenture prostheses in their studies; the use of reinforced frameworks may be an additional factor that reduces the complication rate.[2,12] Therefore, a part of the complications encountered as bar or denture fracture may also be explained by the absence of a framework and the difference in size between the prefabricated round bars and the milled bars.

The present study principally also confirms data that, for IODs with resilient support, the prosthodontic maintenance burden is greatest during the first years of use.[1,2,5] For the resilient system, an increased rate of prosthesis contour modifications was necessary in the retromolar and pear-shaped pad areas, which may correlate with possible bone resorption and often lead to the need for relining/rebasing.[19,31,32] In contrast, with a rigid anchorage system, such as the milled bar, the incidence of prosthodontic maintenance was low—only about a third of that seen with the resilient anchorage system—and evenly distributed throughout the follow-up period.[16] Therefore, postplacement prosthodontic maintenance for IOD has been described as significantly influenced by the anchorage system and especially by bending moments occurring in resilient anchorange systems.[2,26,29] This also explains the pronounced clap activation in the resilient systems as characteristic of hinging overdentures.[2,29,30]

In addition, subjective complaints related to the retention of the opposing maxillary dentures were also evident in this prospective study and differed between the 2 prosthodontic designs used. As a consequence of ongoing atrophic processes, the resilient mandibular anchorage system may result in an unstable occlusal plane.[2,29,30] This may in turn lead to atrophy-induced resorption in the lateral mandibular region and in the edentulous frontal maxillary region.[19,31,32] Thus, resilient mandibular anchorage in edentulous patients may induce complications in the overall maxillomandibular complex, which have also been described by the pathogenesis of the so-called combination syndrome.[33–35] As shown by the high incidence of rebasing of the maxillary prosthesis, the overall stability of the maxillary prosthesis is adversely affected. Thus, clinicians should inform their patients of this possibility during treatment planning and advise them that more frequent relining of maxillary dentures may be needed when resilient mandibular rehabilitation is performed.

Naturally, the fabrication costs of a milled bar with rigid anchorage will be significantly higher than those for the manufacture of conventional (prefabricated, round bars) anchorage elements.[14–16,36–38] However, there is potential for cost savings during the postinsertion maintenance period when it is considered that the resiliently anchored IODs needed more than three times as much maintenance as did the rigidly anchored IODs. Therefore, the benefits and advantages of postoperative care should be considered at the time of original procurement.[2,12,16,36–38] For these reasons, the type of bar should also be discussed for traditional versus immediate loading with an IOD,[2,12,16] since immediate loading of IODs predominantly involves prefabricated parts—ie, round bars—and thus a resilient anchorage system.[2,39–41] Therefore, for immediate loading with resilient anchorage, the advantage of immediate rehabilitation[39–41] may be associated with the clinical drawback of an increase in the expected prosthetic postinsertion maintenance needs.[2,12]

Overall, the null hypothesis was not fulfilled. There were significant differences in postinsertion care between rigid and resilient anchorage systems for IODs after an observation period of 5 years. Therefore, it may be assumed that when more than 2 implants are used to retain an IOD, the design of the anchorage system, ie, the design of the bar architecture, will significantly affect postinsertion maintenance efforts and should thus be considered in overdenture planning.

Conclusion

Based on the data of this 5-year prospective study, the following conclusions can be drawn:

1. When 4 interforaminal implants were used to anchor mandibular overdentures, the design of the anchorage system significantly influenced the need for prosthodontic maintenance and the complication rates.
2. Rigid anchorage systems, such as milled bars combined with metal-reinforced denture frameworks, showed a lesser need for prosthodontic maintenance, eg, matrix activation and repairs and denture margin adaptations, than resilient denture stabilization with multiple round bars and dentures without frameworks.
3. For the round bar design, prosthodontic interventions were concentrated during the first few postinsertion years, whereas prosthodontic interventions with the milled bar design were distributed homogenously over the full observation period.

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Literature Abstract

Survival analysis and clinical evaluation of implant-retained prostheses in oral cancer resection patients over a mean follow-up period of 10 years

This study evaluated the long-term survival of dental implants (435 implants from different manufacturers) and implant-retained prostheses (78 removable and 25 fixed prostheses), in 93 oral cancer resection patients (63 males, 30 females). Twenty-nine patients between the ages of 16 and 89 received postsurgical radiotherapy prior to implant surgery (up to 72 Gy). Three hundred eighty-four implants were placed in the affected jaws, while 51 implants were placed in the opposing jaws. Factors related to implant survival or failure were monitored over a mean observation period of 10.3 years (range of 5 to 161 months). Kaplan-Meier curve and comparisons with the log-rank test or the Wilcoxon test ($P = .05$) were used to evaluate the results. Forty-three of the 435 implants were lost; the cumulative survival rate was 92%, 84%, and 69% after 3.5, 8.5, and 13 years respectively. Twenty-eight implants were counted as lost since the patients had died. Twenty-nine irradiated patients received 124 implants, of which 7 implants were lost (6 prior to prosthodontic rehabilitation as opposed to 4 lost in non-irradiated patients). There was no difference between the survival rates of irradiated or non-irradiated locations or between males and females. In 68 patients with 78 rigid bar-retained dentures, only minor technical complications were identified. The 25 fixed implant-supported restorations had no failures among them. This study shows that implant prostheses in oral cancer resection patients, irrespective of the cancer treatment, have lower long-term survival rates than those in regular patients. Fixed implant-supported prostheses appear to minimize the complication rates. The poor implant survival rate was due to the higher mortality rate, and not to a lack of osseointegration.

Nelson K, Heberer S, Glatzer C. *J Prosthet Dent* 2007;98:405-10. **References:** 20. **Reprints:** Dr Katja Nelson, Department of Oral and Maxillofacial Surgery, Charite Campus Virchow Clinic, Augustenburger Platz 1, 13353 Berlin, Germany. Fax: +49-30-4-50-55-59-01. E-mail: katja.nelson@charite.de—*Majd Al Mardini, Hamilton, Ontario, Canada.*