Patient Satisfaction and Preference with Magnet, Bar-Clip, and Ball-Socket Retained Mandibular Implant Overdentures: A Cross-over Clinical Trial

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Purpose: The purposes of this study were to: *(1)* determine patient satisfaction with implant-supported mandibular overdentures using magnet, bar-clip, and ball-socket attachments; and *(2)* assess the relation between maximum bite force and patient satisfaction. ***Materials and Methods:*** In a cross-over clinical trial, 18 edentulous patients with mandibular denture complaints received two mandibular implants and new mandibular and maxillary dentures. The mandibular denture was initially without any kind of attachment system, but it was fitted with one of the attachment types after 3 months. The attachments were changed 3 months thereafter, in random order. A questionnaire on denture complaints was administered at baseline (with the old denture), after 3 months of function with the new denture without attachments, and after 3 months of function with each of the attachments (within-subject comparison). In addition, patients were asked to express their overall appreciation of their dentures on a VAS. Patients' preferences were determined at the end of the experiment. Maximum bite forces were obtained from a previous study with the same population. Five scales of denture complaints were constructed. Mean scale and VAS scores at the five evaluation points were compared among the groups. Pearson correlation was calculated between maximum bite force and scale and VAS scores. ***Results and Conclusion:*** Mandibular implant-supported overdenture treatment reduced various denture complaints. The VAS score better reflected patients' preferences than did scale score. Patients strongly preferred bar-clip (10/18 subjects) and ball-socket attachments (7/18 subjects) over magnet attachments (1/18 subjects). Patients' preferences could not be predicted on the basis of baseline observations. Maximum bite force was not correlated to scale or VAS score. Hence, patients with higher maximum bite forces were not necessarily more satisfied. *Int J Prosthodont 2005;18:99–105.*

Edentulous patients may experience a wide range of denture problems, including functional complaints related to the mandibular denture. Implant overdenture treatment (IOT) is generally considered to be an effective treatment modality in these cases.[1] Implant loss is relatively rare, and oral function is significantly improved.[2–5] Patients who undergo IOT expect this treatment to solve or at least reduce the denture problems they experience; the benefits they perceive are therefore important outcome variables of IOT, arguably even more important than implant function and survival or measured oral function. Patient-centered approaches to the assessment of treatment efficacy should be considered highly relevant.[6]

Middle-aged and elderly patients who receive IOT are generally more satisfied with their dentures than patients who receive conventional dentures, both in the short and long run.[7–15] In contrast, Kapur et al[16] found no major difference in perceived chewing function after 2 years

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among edentulous patients with diabetes who received a conventional denture or IOT.

Various prosthetic concepts are possible, basically distinguishing between primarily implant-supported or more mucosa-supported overdentures. Tang et al[17] evaluated long-bar and hybrid overdentures in a cross-over study. Patients rated both types of overdentures as comfortable, but most preferred the long-bar overdenture as being more stable, more comfortable, and easier for chewing. Others found no difference in patient satisfaction between implant- and mucosa-supported overdentures.[2,18] Some no longer consider conventional dentures the favored treatment option in the edentulous patient; IOT involving two implants is preferred instead.[1]

Such mucosa-supported overdentures on two implants can receive their retention from magnet, bar-clip, or ball-socket attachments. The authors' group studies the clinical outcome and the effects on oral function of these three types of IOT.[4,5,19] The present study focused on the effect of IOT on patient satisfaction and preference. More specifically, the bearing of the attachment type (magnet, bar-clip, or ball-socket) on denture complaints was evaluated in a cross-over clinical trial. Patient preference was determined, and whether this ultimate choice of attachment type can be based on baseline data was evaluated. In addition, the relationship between maximum bite force and patient satisfaction among subjects who all received three different types of implant-supported overdentures was assessed.

Materials and Methods

Patient Population and Surgical Procedure

Eighteen edentulous subjects from the Royal Dutch Army and Air Force participated in this randomized cross-over clinical trial. They were referred to the Centre for Special Dental Care of the Central Military Hospital in Utrecht, The Netherlands, because of functional complaints with their mandibular dentures. The group consisted of 1 woman and 17 men ranging in age from 33 to 56 years, all healthy and fit for military service. The bone height in the interforaminal region exceeded 15 mm. Two oral implants (Frialit-2, Friadent) were placed according to a standardized surgical protocol (see Van Kampen and coworkers[4,19] for more details).

Prosthodontic Procedure

Prosthodontic procedures were started 1 week after first-stage surgery. New conventional maxillary and mandibular dentures were made according to a standard prosthetic scheme that included balanced articulation using anatomically shaped acrylic resin teeth (Bonartic, Ivoclar Vivadent), maximal extension of the denture base, and restoration of the vertical relation. In addition to anterior teeth, one premolar and two molars were used in the denture in each quadrant. One week following second-stage surgery, the healing abutments were removed and pickup impression posts were placed at the implant level. A master cast was poured, and one of three different attachment types was incorporated in the existing newly made denture:

- Magnet attachment (Dyna Magnet ES, type extra strong, Dyna Dental Engineering): According to the manufacturer, the magnets provide a 4.4-N retention force each. The magnet keepers were specially manufactured for this trial by Friadent and are not commercially available. Magnets were fit into the denture base according to the manufacturer's instructions.
- Bar-clip attachment (round bar in conjunction with metal, omega-shaped IMZ clip, Friadent): The retention force for this attachment is not documented by the manufacturer.
- Ball-socket attachment (Frialit-2): The retention force for this attachment is not documented by the manufacturer.

A previous in vivo study showed that the mean force needed to dislodge an overdenture supported by two implants with these magnet, bar-clip, and ball-socket attachments is 8.1 N, 31.3 N, and 29.7 N, respectively.[19]

The attachment type was changed after 3 and 6 months, in random order. Because the same denture base was used, similar occlusion, articulation, height, and denture base extension were maintained during the course of the trial (see Van Kampen and coworkers[4,19] for details).

Evaluation Points and Outcome Measures

Data were gathered prior to implant treatment (old denture), just prior to second-stage surgery (new denture without attachments, after 3 months of function), and after 3 months of function with each of the attachment types (overdenture). Subjects were invited to express their opinions regarding several denture complaints presented to them on a list. This list had a four-point scale: 0 = no complaints; 1 = minor complaints; 2 = moderate complaints; and 3 = severe complaints. The list is similar to the one developed by Vervoorn et al[20] and was also used by other groups evaluating satisfaction with mandibular IOT.[2,8,13,21] They constructed six scales of denture complaints by means of the principal factors method (Table 1). The reliability of the constructed scales, measured by calculating internal consistency and expressed as Cronbach's alpha,

Table 1 Scales of Denture Complaints Constructed[21]

Scale	Example complaints
Maxillary denture (9 items)	"Maxillary denture loosens while eating" "Maxillary denture loosens while speaking" "Maxillary denture hurts while eating hard food types" "Burning sensation underneath maxillary denture"
Mandibular denture (9 items)	"Mandibular denture loosens while eating" "Mandibular denture loosens while speaking" "Mandibular denture hurts while eating hard food types" "Burning sensation underneath mandibular denture"
General (18 items)	"Dry mouth" "Chewing is difficult" "Teeth and molars from maxillary and mandibular dentures make contact while speaking" "Nervousness because of the dentures"
Physiognomy (3 items)	"Lip has fallen in" "Cheeks have fallen in" "Mouth has fallen in"
Neutral space (4 items)	"Tongue has too little space" "I bite my tongue" "I bite my cheeks" "I bite my lip"
Esthetics (11 items)	"Teeth are too large" "Teeth are too white" "You don't see enough teeth" "Teeth are not positioned the way I would like them to be"

is satisfactory, shows little variation, and ranges between .76 and .89, depending on the study and scale. The authors constructed the same scales.[21,22]

In addition, the subjects were asked to grade their dentures (overall satisfaction) on a visual analogue scale (VAS) ranging from 0 to 100 mm. The subject was requested to place a dot on this line; the distance from zero represented the degree of overall satisfaction. The higher the score, the more satisfied the subject.

Finally, at the end of the experiment and after having tried all of the attachment types, the subjects were asked which one they preferred. This attachment type was subsequently (re)built into the denture. Whether the subjects' final choices could be predicted on the basis of the mean scale scores and VAS scores with the old denture at baseline was investigated.

Maximum bite force measurements were obtained from a previous study with the same patient population.[4] Vertical interocclusal bite forces were measured bilaterally with a bite force tranducer. This device, which has been described in detail,[23] consists of a bite fork equipped with strain gauges on the right and left parts of the mouthpiece. The strain gauges were positioned between the occlusal surfaces in the first molar region. The bite force transducer was covered with dental impression material that fit the shape of the subject's teeth. In this way, a reproducible bite position was obtained for all bite force measurements during the 14-month period.

Statistical Analysis

The data were analyzed by means of a standard statistical program (SPSS, version 9.0 for Windows, SPSS). Mean scores were calculated for the six scales (Table 2). Repeated-measures analysis of variance (ANOVA) with Greenhouse-Geisser correction factor was applied to test the null hypothesis that there would be no statistical difference between the different scale scores and VAS score for the old denture, new denture without attachment, and overdenture with the magnet, bar-clip, and ball-socket. Subsequently, post hoc tests were used for pairwise comparison of results.

Because patients expressed their preference at the end of the experiment, subsets of subjects could be identified by preference (those who preferred the magnet, bar-clip, and ball-socket attachments). Whether these patients had a different profile with respect to the level of complaints when entering the experiment was evaluated. One-way ANOVA was applied to test the null hypothesis that there would be no statistical difference in scale scores and VAS score at baseline (old denture) among the subsets. The correlation between the maximum bite force and the scale scores and VAS scores for the three types of implant-supported overdentures was calculated by means of the Pearson correlation test.

Table 2 Mean (Standard Deviation) Scale Scores* and Differences Among Suprastructure Types

Scale	Old denture (1)	New denture without attachment (2)	Overdenture with magnet attachment (3)	Overdenture with bar-clip attachment (4)	Overdenture with ball-socket attachment (5)	*P* value†	Contrasts‡
Maxillary denture	0.51 (0.36)	0.18 (0.28)	0.21 (0.26)	0.25 (0.29)	0.31 (0.40)	.004	$2^{=}3^{=}4^{=}5^{<}1$
Mandibular denture	1.57 (0.68)	1.10 (0.63)	0.40 (0.26)	0.17 (0.16)	0.12 (0.09)	< .001	$4^{=}5^{<<}3^{<<<}2^{<<<}1$
General	0.77 (0.37)	0.44 (0.35)	0.21 (0.17)	0.15 (0.14)	0.12 (0.12)	< .001	$4^{=}5^{<}3^{<<}2^{<<}1$
Physiognomy	0.80 (0.68)	0.07 (0.18)	0.07 (0.24)	0.15 (0.30)	0.04 (0.16)	.001	$2^{=}3^{=}4^{=}5^{<<<}1$
Neutral space	0.49 (0.38)	0.13 (0.21)	0.24 (0.28)	0.16 (0.24)	0.18 (0.26)	.003	$2^{=}3^{=}4^{=}5^{<}1$
Esthetics	0.32 (0.34)	0.08 (0.20)	0.07 (0.11)	0.06 (0.10)	0.07 (0.06)	.007	$2^{=}3^{=}4^{=}5^{<<}1$

*Range: 0 = no complaints; 1 = minor complaints; 2 = moderate complaints; 3 = severe complaints.
†Repeated-measures analysis of variance.
‡Differences among suprastructure types (1 to 5):
$^{=}P > .050$;
$^{<}P < .050$;
$^{<<}P < .010$;
$^{<<<}P < .001$.

Table 3 Mean (Standard Deviation) Visual Analogue Scale (VAS) Scores* and Differences Among Suprastructure Types

	Old denture (1)	New denture without attachment (2)	Overdenture with magnet attachment (3)	Overdenture with bar-clip attachment (4)	Overdenture with ball-socket attachment (5)	*P* value†	Contrasts‡
VAS score	14.6 (13.4)	39.6 (17.1)	60.2 (19.3)	85.2 (14.4)	86.2 (11.4)	< .001	$1^{<<<}2^{<<}3^{<<<}4^{=}5$

*Range 0 to 100 mm.
†Repeated-measures analysis of variance.
‡Differences among suprastructure types (1 to 5):
$^{=}P > .050$;
$^{<<}P < .010$;
$^{<<<}P < .001$.

Results

Scale Scores

Mean scale scores and differences among suprastructure types are shown in Table 2. There was a statistically significant difference in scale scores between the five groups on all scales (one-way ANOVA).

- Maxillary denture scale: The subjects experienced fewer denture complaints with their new maxillary dentures in combination with a mandibular denture without attachments when compared to their old ones. The subjects did not experience a marked difference in maxillary denture function between the dentures without (old or new) and with the attachment system (magnet, bar-clip, or ball-socket).
- Mandibular denture scale: Mandibular denture complaints were already reduced by making a new conventional denture, but subjects rated the mandibular dentures with any of the attachment types better than the conventional dentures (old or new). No statistically significant difference in mandibular denture complaints could be demonstrated among the three attachment types.
- General scale: Subjects experienced most general denture complaints with their old dentures, whereas the dentures with the bar-clip and ball-socket attachments scored best on this scale. Fitting magnets to a new conventional denture did not noticeably improve patient satisfaction with respect to the items in this scale.
- Physiognomy, neutral space, and esthetics scales: Most complaints with respect to these scales were expressed with the old dentures. The new conventional dentures were considered better, but there was no marked subjective improvement when the new dentures were fitted with any of the attachments. This was expected, as the new denture base remained the same throughout the experiment.

VAS Score

The mean VAS scores and differences among the groups are presented in Table 3. Patients already experienced a significant improvement in overall denture satisfaction with the new denture without any attachment. A major improvement was seen when an attachment was fitted in the denture. Subjects favored the bar-clip and ball-socket attachments.

Subjects' Preferences

At the end of the experiment, the subjects were asked which of the three attachment types they preferred. Of the 18 subjects, 1 preferred the magnet attachment, 7 preferred the ball-socket attachment, and 10 preferred the bar-clip attachment. The 1 subject who choose the magnet attachment stated: "It was easier to clean food particles from underneath the mandibular denture with my tongue, without having to remove the denture from my mouth." The 7 patients who choose the ball-socket argued that: "The mandibular denture was very stable while chewing and biting," "the ball-socket attachments were easier to clean than the bar-clip attachment," "no food particles came under the mandibular denture," "the ball-socket attachment provided the most comfort," and "with sneezing and laughing, the mandibular denture with ball-socket attachments remained seated." For the 10 patients who choose the bar-clip attachments, the following issues were important: "The mandibular denture with the bar-clip attachment provided the most stable fit during chewing and biting in comparison to the other two attachments," "the construction felt strong and secure," and "despite more effort needed to clean the attachment, I liked it better because it provided the best comfort." One-way ANOVA did not reveal statistically significant differences in baseline values for the VAS or scale scores between the three groups. Thus, patients' preferences could not be predicted on the basis of the baseline data.

Correlation with Maximum Bite Force

The Pearson correlations between the scale scores and maximum bite force were as follows: maxillary denture –.09, mandibular denture .06, general –.23, physiognomy –.06, neutral space –.04, and esthetics –.02. They were all low and statistically nonsignificant.

Discussion

Patients already express a reduction in denture-related complaints when a new denture is made, even without the benefits of implant anchorage. This subjective improvement in denture function cannot be substantiated by objective measures. Earlier studies involving the same population reveal a significant reduction in maximum bite force and food comminution with the new denture without attachment after 3 months of function when compared to the old denture. This is attributed to adaptation problems.[4,5] The possibility that subjects are tempted to offer socially desirable ratings regarding the function of the new denture (social desirability bias) cannot be overlooked, especially as the new denture, in contrast to the old denture, was made by one of the authors. When any of the attachment types was fitted into the denture, patient satisfaction was improved. This is in agreement with observations in other studies.[7,13,14,20] The scale scores for the old denture and the overdenture with the bar-clip attachment are in reasonable agreement with others[21] who used the same questionnaire and scale composition. It should be noted that their postoperative measurements were obtained after 1 year, whereas the data in the present study were gathered after 3 months of function.

The present study had a cross-over design. In contrast to longitudinal study designs, patients had the opportunity to experience all treatment modalities and were able to compare them personally (and finally choose the one they liked best). Because edentulous patients who seek mandibular implant treatment experience serious problems and treatment is usually highly successful, "ceiling effects" are common when using questionnaires. Patients tend to score toward the end of the scale score both before and after treatment. Ceiling effects pose a psychometric problem, making it difficult to qualitatively differentiate between treatment options. Interestingly, the VAS scores far better expressed the subjects' sentiments compared to the scale scores in the present study. They were in better agreement with patients' ultimate preferences than were the scale scores. Subjects preferred ball-socket (7/18 subjects) or bar-clip attachments (10/18 subjects) and liked magnet attachments (1/18 subjects) far less. This is not consistent with most of the scale scores. Hence, the (additional) value of a questionnaire for this type of investigation is doubtful. A VAS score may suffice and be more practical.

Several other groups compared patient satisfaction in groups of patients with either a Dolder bar or ball-socket attachment and found a comparable level of patient satisfaction among their groups.[24–26]

Burns et al[27] evaluated O-ring and magnet attachments in a cross-over study design. Although patients were satisfied with both attachment types, they showed a strong preference for the O-ring attachment. In another study,[26] patients with ball-socket attachments were more satisfied than patients with magnet attachments, although both attachment types provided patient satisfaction. Naert et al[28] report on patient satisfaction after 5 years among three groups of patients who received bar-clip, O-ring, or magnet attachments. Although the patients in the magnet group stated that they would have preferred a more retentive attachment system, patient satisfaction among the groups was comparable. A national investigation found no difference in subjective treatment result among patients with different suprastructure types.[7]

The lack of correlation between the objective outcome measure "maximum bite force" and the subjective

outcome measures presented by the scale and VAS scores is interesting. Patients who can bite harder are not necessarily more satisfied; consequently, just raising bite force levels does not automatically create happier patients. Patients' preferences could not be reliably predicted on the basis of the data obtained at baseline. Therefore, baseline data cannot guide the prosthodontist in choice of attachment, although a mucosa-supported overdenture on two implants with magnets does not seem to be a popular choice from the patient's perspective. This is in agreement with most of the studies mentioned above.

Other aspects should also be considered. Short-term results indicate that ball-socket and bar-clip retained overdentures on two implants result in similar maximum bite force, chewing efficiency, clinical performance, and maintenance and repair requirements.[4,5,19,29] In the present study, only one patient finally choose a magnet attachment in his mandibular denture, whereas seven patients chose the ball-socket and ten patients opted for the bar-clip attachment. Patients from the latter two groups expressed similar arguments and benefits for choosing either the ball-socket or bar-clip attachment. These two attachment types provide the best and similar resistance against dislodging forces,[19] which is highly valued by patients. It makes them feel more secure. Patients' preferences reflect the difference in retention between bar-clip and ball-socket attachments on the one hand and magnet attachments on the other.

In the present study, common magnet attachments were used (see Van Kampen et al[19]). They were fit into the denture base according to the guidelines provided by the manufacturer. Thus, no form of horizontal stabilization to provide resistance against horizontal dislodgment (ie, a housing of some kind) was implemented in the denture base. As a result, the magnet attachments operated at a disadvantage in this respect. Nevertheless, earlier studies demonstrate that chewing efficiency and maximum bite force among the attachments types are more or less similar.[4,5] The literature suggests that ball-socket attachments loose part of their retention in the longer run, which understandably has an impact on patient satisfaction.[30] This seems an easily manageable problem within a practical, effective, and relatively low-cost prosthetic concept. O-ring attachments seem to function well, even in the long run, but they require frequent maintenance (ie, replacement of the O-ring housings).[31] Choosing between bar-clip and ball-socket attachments in mandibular IOT on rational grounds remains difficult.

Mandibular IOT was effective in reducing a wide range of denture complaints. Patients strongly preferred bar-clip and ball-socket attachments over magnet attachments, but their preference could not be predicted on the basis of baseline observations. A VAS score better reflected patients' preferences than did scale score. Maximum bite force was not correlated to scale or VAS score.

Acknowledgments

This study was supported in part by the University Medical Center Utrecht, Military Hospital Utrecht, The Netherlands Institute for Dental Sciences and Friadent. The laboratory procedures were performed by the Dental Laboratory of the University Clinic of Utrecht and the Zeister Tandtechnisch Laboraratorium, Zeist, The Netherlands. The authors wish to thank Dr C. Stellingsma for providing information on which construction of the scales used in this article was based.

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Literature Abstract

Subantimicrobial dose doxycycline enhance the efficacy of scaling and root planing in chronic periodontitis: A multicenter trial

Regeneration of periodontal attachment is able to improve biomechanical conditions in restorative dentistry. In this multicenter study, investigators looked for the enhancement of subantimicrobial dose doxycycline (SDD) with scaling and root planing (SRP). Two hundred and ten subjects at six dental schools in the United States participated in the study. The evaluated sites were stratified by the degree of pocket depth at baseline (1 to 3 mm, 4 to 6 mm, and 7 mm and more). Following SRP (four 1-hour sessions), subjects were randomized to receive SDD 20 mg bid or placebo bid for 9 months. At 3, 6, and 9 months after baseline, clinical attachment level (CAL) and pocket depth were measured. A total of 157 subjects completed the study (89 in the SDD group, 68 in the placebo group). Analysis of variance was used for statistics ($P < .05$). At 9 months, CAL gains were significantly greater in the SDD group than in the placebo group. The reductions in pocket depth were significantly greater in the SDD group as well. The treatment-emergent adverse events were similar in both groups and were not significant. Smoking did not present a bias in this study. The authors concluded that the combined therapy with SRP and adjunctive host response modulation (ie, SDD) statistically and clinically improved the stabilization of the periodontium and periodontal status more than when SRP only was used. These significant clinical benefits would reduce the need for further treatment.

Preshaw PM, Hefti AF, Novak MJ, et al. *J Periodontol* 2004;75:1068–1076. **References:** 25. **Reprint:** Dr Philip M. Preshaw, Department of Periodontology, School of Dental Sciences, University of Newcastle upon Tyne, Farmington Place, Newcastle upon Tyne, NE24BW U.K. e-mail: p.m.preshaw@ncl.ac.uk—*Eunghwan Kim, Lincoln, NE*