A Comparison of Implant-Supported, Bar- or Ball-Retained Mandibular Overdentures: A Retrospective Clinical, Microbiologic, and Immunologic Study of 10 Edentulous Patients Attending a Recall Visit

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Purpose: Clinical, microbiologic, and immunologic comparisons of the peri-implant health in edentulous volunteers wearing long-standing implant-supported ball- or Dolder bar–retained mandibular overdentures were performed. ***Materials and Methods:*** Ten age- and gender-matched individuals (mean age, 71 years) with either ball- or bar-retained complete mandibular overdentures, scheduled for an annual implant recall examination, were investigated an average of 7 years after implant placement. Plaque and gingival crevicular fluid samples were obtained from the peri-implant sulcus. The groups were compared with regard to peri-implant probing depth; plaque and bleeding on probing scores; sulcular fluid flow rates; implant stability measurements (Periotest device); relative concentrations of *Actinobacillus actinomycetemcomitans, Prevotella intermedia, Fusobacterium nucleatum, Porphyromonas gingivalis, Tannerella forsythensis,* and *Treponema denticola* assessed by polymerase chain reaction analysis; and sulcular concentrations of interleukin-1β and prostaglandin E2, assessed by enzyme-linked immunosorbent assay. ***Results:*** No statistically significant differences were found for any of the examined parameters between both study groups. ***Conclusion:*** Within the limitations of this study, both ball attachments and Dolder bars can be recommended for overdenture retention, with either one showing satisfying clinical, microbiologic, and immunologic findings in the peri-implant tissues after several years of service in healthy recall patients with good oral hygiene habits. *Int J Prosthodont 2007;20:37–42.*

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The retention of complete mandibular dentures by means of oral implants is a therapy widely appreciated by both patients and practitioners.[1–7] Various methods to connect overdentures and implants have been described. Industrial balls and cast round or oval (eg, Dolder) bar attachments are frequently used. Several studies have examined possible differences between these attachment options in terms of denture stability and retentive forces, peri-implant attachment loss, financial aspects of treatment, degree and frequency of long-term complications, patient satisfaction,[8–27] and clinical peri-implant findings.[14,20,28–30]

Because of the nature of the prosthetic construction, the free space within the denture base around the attachment clips is larger in bar-retained prostheses than in ball-retained dentures. It is common sense, then, that greater volumes of plaque may be found within these spaces in bar-retained dentures, especially

if the bar is not custom-milled. Since initially good oral hygiene standards tend to worsen over time[31] and plaque accumulation will occur in most patients some time after prosthesis delivery, it is possible that one of these attachment systems may favor a specific pathologic microflora and may induce peri-implant inflammation more often than the other. One publication on clinical findings found no difference between these treatment options.[14]

To the knowledge of the authors, no study to date has addressed the peri-implant microbiology or local immunologic factors of the host response in patients with different overdenture attachments. The aim of this study was therefore to investigate the presence of 5 putative pathogenic bacteria and the concentration of the inflammation markers interleukin-1β (IL-1β) and prostaglandin E2 (PGE2) in sulcular fluid samples of edentulous patients wearing Dolder bar– and ball-retained mandibular overdentures, who were recruited consecutively from an annual implant maintenance program an average of 7 years after implant and prosthesis placement.

Materials and Methods

Patient Characteristics

From a university implant registry, 21 edentulous patients with conventional complete maxillary and implant-supported mandibular overdentures, who had scheduled their annual recall visit and had provided written informed consent, were asked to participate in the study. The study protocol had been approved by the local ethical committee. Of these patients, 5 individuals wore ball-retained prostheses. From the remaining 16 individuals with Dolder bar attachments, 5 were hand selected to match pairwise for gender and most closely for age; the remaining 11 patients were excluded from the study. The person selecting the individuals was unaware of their clinical status. Thus, 5 patients, each matched exclusively for age and gender, formed the ball- and Dolder bar–attachment groups. One or more of the following conditions would have resulted in exclusion from the study: tobacco smoking, systemic or local intraoral antibiotic therapy within the past 3 months, an intraoral infection or inflammation of any cause, immune deficiency, a diabetic condition, a rheumatoid disease, head or neck radiation therapy, or anticoagulation therapy.

All patients were lifetime nonsmokers and had received 2 mandibular implants in the interforaminal region on average 7 years prior to the study appointment (median 7; range, 1 to 12 years). The mean age of the 2 men and 8 women was 71 years (median 72; range, 66 to 76 years). Because of a shift in treatment strategy that had taken place at the investigators' clinic, there was a noticeable difference in wearing time of the implants between both groups. Patients with Dolder bars had received their implants an average of 10 years before the onset of the study, whereas patients with ball-retained dentures had received the implants an average of 3 years before the study began. For that reason, patients could not be matched for implant-wearing time.

Implants and Prosthodontic Rehabilitation

The characteristics of the patients and implants can be seen in Table 1. Bonefit implants (Institut Straumann) had been placed according to a transgingival unloaded healing protocol, and the other implants were left submerged until second-stage surgery. All implants were loaded approximately 3 months after placement. No augmentation had been necessary for implant bed preparation in any of the patients.

All dentures had been fabricated with hot-curing acrylic resin and had been mounted with shallow-cusp acrylic resin teeth. The dentures were attached to either commercial ball attachments specific to the implant system used or to individually fabricated Dolder bars with commercial gold clips. The female parts of the attachments were intraorally connected to the denture base by use of self-curing acrylic resin at the time of prosthesis delivery or, in case of clasp renewal, during a recall visit. Finishing of the surfaces in these instances was done in a dental laboratory prior to patient dismissal. A 1-mm clearance space was left around the ball clips in the denture base with a rubber space holder to facilitate clip activation in cases of retention loss. During fabrication of the dentures, the laboratory technician left significantly more space in the denture base around bar clips than around the ball attachments owing to the nature of the attachment design, ie, to allow for freedom of prosthetic movement around the bar and implants during function.

The functional masticatory concept used for these patients was a bilaterally balanced occlusion. It was checked annually and adjusted accordingly, if necessary. Relining with self-curing resin was performed in the dental laboratory on average every other year from functional silicone impression patterns of the denture base.

Clinical Investigative Procedures

Along with a conventional oral hygiene assessment and functional checkup, oral hygiene assessments (see following) were recorded in each patient 1 week before and again 1 hour prior to the implant recall session and performance of oral hygiene measures. The measurement mean of both visits was used in statistical analyses.

Table 1 Patient and Implant Characteristics

Patient	Gender	IL-1 genotype	Year of birth	Year of implant placement	Denture attachment	Implant system
1	Female	Negative	1928	2002	Ball	Frialit-2, Friadent
2	Female	Negative	1930	1993	Dolder bar	Bonefit, Institut Straumann
3	Female	Negative	1927	1998	Ball	Frialit-2, Friadent
4	Female	Negative	1928	1994	Dolder bar	Bonefit, Institut Straumann
5	Female	Positive	1935	1992	Dolder bar	IMZ, Friadent
6	Female	Positive	1933	1993	Dolder bar	IMZ, Friadent
7	Female	Negative	1938	1999	Ball	Frialit-2, Friadent
8	Female	Negative	1929	2002	Ball	Frialit-2, Friadent
9	Male	Positive	1937	1992	Dolder bar	Brånemark, Nobel Biocare
10	Male	Positive	1935	2002	Ball	Frialit-2, Friadent

Probing of the peri-implant pocket was done at 4 sites per implant (mesial, distal, buccal, labial), and the mean value was used in calculations. The plaque score ranged from 0 to 2; bleeding on probing scores were recorded dichotomously (present = 1, absent = 0). Damping capacity assessment (Periotest instrument, Gulden Messtechnik) was recorded with a custom-made Periotest abutment for each implant system in triplicate, and the 3 consecutive standardized measurements were converted into mean values.

Gingival crevicular fluid (GCF) was collected with prefabricated sterile paper strips (PerioPaper, Proflow Inc). To do this, the implant crevice was swept clean with sterile cotton pellets, carefully dried with air, and meticulously kept clean from moisture contamination with a saliva ejector and cotton rolls placed in the vestibulum and sublingual space. Then the paper strip was inserted 1 mm into the peri-implant sulcus and retrieved after 60 seconds. The sampling procedure was repeated after 5 minutes with another paper strip. The GCF volume was calculated as the sum of both measurements, recorded in microliters per 120 seconds of flow with the Periotron device (Harco Electronics). Immediately after determination of GCF volumetry, both paper strips were inserted into a transport tube with 100 µL of 1:1 diluted phosphate-buffered saline solution and stored at –70°C until processing in the laboratory. The amount of IL-1β and PGE2 in the GCF was determined with enzyme-linked immunoassay (ELISA) (IL-1β: Roche; PGE2: R&D Systems).

Microbial samples were taken with 2 no. 40 sterile endodontic paper points that were gently introduced into the sulcus and then left in place for 30 seconds each. Both paper points were placed into 1 empty tube and stored at –70°C until processing.

Relative concentrations of the following 5 pathologic bacteria from the peri-implant sulcus were assessed with a commercially available polymerase chain reaction (PCR) kit: *Actinobacillus actinomycetemcomitans, Prevotella intermedia, Porphyromonas gingivalis, Tannerella forsythensis*, and *Treponema denticola* (MicroDent, Hain LifeScience). The patients' IL-1 genotype was determined with commercial PCR diagnostics as well (PST Periodontal Screening Test, Hain LifeScience).

Each diagnostic procedure was repeated 1 week later at the second visit before the oral hygiene session, with the exception of assessment of the IL-1 genotype, as this genetic finding was not prone to change during the observation period or the patient's lifetime.

Statistical Analysis

The unit of analysis was the implant itself, as recommended by Bland and Altman[32]; thus the mean of each finding's measurement and its repetition 1 week later was used. First, only 1 implant per patient was randomly chosen for analyses (groups A and B) to avoid calculations with dependent observations. In these calculations the number of implants investigated was thus equal to the number of study patients (n = 10). All calculations were performed on both groups A and B of both implants in each patient to check for bias caused by the randomization process. In a second set of calculations, both implants in each patient were then included to increase the number of units analyzed (n = 20). Statistical analyses included explorative data analysis and the *t* test. As usual, statistical significance was set at $P < .05$. Associations were considered clinically significant only if statistical significance was shown for both (A and B) implant groups.

Results

Table 2 shows the measurements as calculated means of both visits. Hygiene findings, mean pocket probing depths, and Periotest measurements suggested that all

Table 2 Findings in Each Patient, with All Implants Randomly Divided into Groups A and B

Group/ patient no.	Attachment mode	GCF (μL/120 s)	Bacteria score*					GCF concentration (ng/mL)		Plaque score†	BOP score†	Probing depth (mm)‡	Periotest value§
			Aa	Pg	Pi	Tf	Td	IL-1β	PGE2				
A													
1	Ball	1.1	0	0	0	0	0	0	30.8	1	1	2.1	−5.7
2	Bar	2.4	0	0	1	0	0	11.4	64.5	0.5	0.5	2.4	−6.0
3	Ball	1.5	0	0	0	0	0	0	34.0	0	0	2.0	−4.5
4	Bar	0.5	0	0	0	0	0	1.5	73.0	1	1	2.6	−4.7
5	Bar	2.0	0	0	0	0	0	10.0	40.0	1.5	1	2.6	−5.8
6	Bar	1.3	0	0	0	0	0	0.7	39.4	1	0.5	2.0	0.3
7	Ball	1.1	0	0	0	0	0	0.9	47.4	1	1	2.8	−4.0
8	Ball	0.9	0	0	0	0	0	35.2	47.8	1.5	1	2.5	−3.3
9	Bar	1.3	0	0	0	0	0	6.1	31.6	0.5	0.5	1.1	−0.7
10	Ball	3.0	0	0	0	0	0	0	9.1	0	0	2.0	−2.5
B													
1	Ball	0.3	0	0	0	0	0	4.7	131.9	0	0.5	2.0	−4.7
2	Bar	3.0	0	0.25	0	0	0	2.4	22.2	0	0.5	2.1	−5.7
3	Ball	0.8	0	0	0	0	0	12.3	172.4	0	0	1.8	−4.0
4	Bar	1.9	0	0	0	0	0	7.1	16.6	1.5	1	2.8	−4.5
5	Bar	2.3	0	0	0	0	0	17.6	13.6	1.5	1	2.6	−3.3
6	Bar	2.4	0	0	0	0	0	0	13.2	0.5	0	2.1	−4.3
7	Ball	0.8	0	0	0	0	0	143.2	59.0	1	1	2.8	−4.0
8	Ball	1.7	0	0	0	0	0	37.8	47.9	1.5	1.5	2.5	0.0
9	Bar	1.5	0	0	0	0	0	1.7	34.7	0.5	0.5	1.0	−5.0
10	Ball	3.0	0	0	0	0	0	0	6.9	1.5	1	2.3	−4.3

Values are given as means of 2 consecutive assessments on 2 appointments 1 week apart without intervening treatment interventions.
*PCR analysis of *Actinobacillus actinomycetemcomitans* (Aa), *Porphyromonas gingivalis* (Pg), *Prevotella intermedia* (Pi), *Tannerella forsythensis* (Tf), and *Treponema denticola* (Td); range, 0 to 3.
†Calculated means; original range 0 to 1.
‡Mean of 4 circular sites measured to the nearest millimeter (mesial, distal, buccal, labial).
§Mean of 3 repetitions.

patients could be considered free from peri-implant infections and loss of attachment at the time of the investigation at either implant. PCR diagnostics identified a minimal presence of *P intermedia* and *P gingivalis* in 1 individual only.

Intraindividual differences in the measurements between the 2 implants (A and B) were not statistically significant (Tables 3 and 4). Likewise, no statistically significant differences were found for any of the measurements between ball-retained and Dolder bar–retained overdentures, regardless of whether both implants (A and B pooled together) per patient or only 1 per patient (either A or B) were included in the statistical calculations. Table 3 depicts the means and the calculated *P* values of measurement differences between the 2 attachment options (ball versus Dolder bar) and between the 2 implant groups (A and B). Table 4 shows the differences first between the implant groups (A and B) and then between the 2 attachment options and the associated *P* values.

Discussion

Periodontal research has shown that supragingival biofilm contains pathogenic bacteria species and may moreover act as a reservoir for recolonization of the sulcus after periodontal therapy.[33] If gaps between components of prosthetic rehabilitations in the vicinity of the peri-implant sulcus harbor bacteria that are associated with peri-implant attachment loss, a similar effect may be expected in the peri-implant tissues. Suspected differences in plaque composition of different intraoral microenvironments caused by variations in the gap morphology, as seen between ball- and bar-retained prostheses, may then influence the microbiologic colonization of these tissues. These differences in turn should then be reflected in the peri-implant health.

The data from the present investigation prove this hypothesis wrong for the patients studied. Instead, the results show that the peri-implant tissues in all patients investigated were healthy, from a clinical point of view, regardless of the mode chosen to attach the dentures to the implants. Because GCF volumes and the measured concentrations of the immunologic factors addressed in this study are dependent on the harvesting and analytic methods employed, no reference values from the literature are available for comparison. Beyond that, no studies on peri-implant microbiology or immunology with regard to different attachment options of mandibular overdentures are known to the authors. Studies comparing clinical findings (such as plaque scores and bleeding on probing), however, support the results of the present study, with their conclusions that the morphology of the mesostructure connecting

Table 3 Mean Values for IL-1β and PGE2 in All Subgroups of Patients and Implants Analyzed, by Attachment Mode*

		Patients stratified into attachment modes with left and right implant randomized into 2 groups			Left and right implants pooled together			Overall means	
Parameter/ attachment mode	Implant ID (randomization group)	Units of analysis†	GCF concentration (ng/mL)	*P*	Units of analysis†	GCF concentration (ng/mL)	*P*	Units of analysis†	GCF concentration (ng/mL)
IL-1β									
Ball	A	5	7.2	.3	10	13.4	.2	20	9.6
	B	5	19.6						
Bar	A	5	5.9	.9	10	5.9			
	B	5	5.8						
PGE2									
Ball	A	5	33.9	.1	10	58.7	.2	20	46.8
	B	5	83.6						
Bar	A	5	49.7	.01	10	34.8			
	B	5	19.8						

*n = 5 patients with ball-attached and 5 patients with bar-attached overdentures, 2 implants called A and B in each patient. Stratification for attachment mode and calculated *P* values for differences in measured means between both implant groups in each attachment option and between both attachment options themselves.
†No. of implants included in statistical calculations (1 or both implants per patient).

Table 4 Mean Values for IL-1β and PGE2 in All Subgroups of Patients and Implants Analyzed, by Implant Group*

		Patients' left and right implants randomly divided into 2 groups and stratified into attachment modes			Both attachment modes pooled together in each implant group			Overall means	
Parameter/ attachment mode	Implant ID	Units of analysis†	GCF concentration (ng/mL)	*P*	Units of analysis†	GCF concentration (ng/mL)	*P*	Units of analysis†	GCF concentration (ng/mL)
IL-1β									
A	Ball	5	7.2	.9	10	6.6	.3	20	9.6
	Bar	5	5.9						
B	Ball	5	19.6	.2	10	12.7			
	Bar	5	5.8						
PGE2									
A	Ball	5	33.9	.2	10	41.8	.6	20	46.8
	Bar	5	49.7						
B	Ball	5	83.6	.1	10	51.7			
	Bar	5	19.8						

*No. of implants included in statistical calculations (1 or both implants per patient).

implants and prostheses does not seem to influence peri-implant health.[14,20,28–30,34]

One severe limitation of this study is, of course, the small number of participants investigated; therefore, caution should be taken to avoid overestimating the conclusions made here. Because of the study design, it cannot be determined whether potentially failing Dolder bar or ball-attachment cases had already dropped out before the onset of the study. Such circumstances may cause bias, which can be ruled out in a prospectively designed study only.

The space and thus the microenvironment within the denture base allows plaque formation around the prosthetic connector, the implant abutment, and the mesostructure, and it may therefore be colonized by pathogenic species. The morphology of this space varies between bar and ball attachments. Still, there seems to be no influence on clinical, microbiologic, and selected local biochemical factors of peri-implant health between patients wearing ball-retained or those wearing round bar–retained overdentures. Both the ball attachment and the Dolder bar can be recommended for overdenture retention, with both showing satisfactory clinical, microbiologic, and immunologic conditions in the peri-implant tissues after several years of service in healthy recall patients with good oral hygiene habits.

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