

# Satisfaction level and masticatory performance of patient rehabilitated with implant-supported overdentures

## Nível de satisfação e performance mastigatória de pacientes reabilitados com sobredentaduras suportada por implantes

### Abstract

**Purpose:** To compare the masticatory performance and satisfaction levels of subjects with normal dentition and subjects with implant-supported overdentures with two types of attachments (ball and bar-clip retention systems).

**Methods:** The sample comprised 24 subjects, 12 edentulous patients and 12 dentate subjects. The denture wearers received two dental implants and new maxillary and mandibular dentures. Three months after the first surgical phase, the mandibular dentures were connected to the implants by a gold ball attachment. Two months later new mandibular overdentures were made with a bar-clip attachment. Satisfaction levels (modified OHIP-EDENT and verbal rating scale) and masticatory performance (chewing for 40 masticatory cycles) were measured with the old dentures, with the unattached new dentures, and with the new dentures with ball and bar-clip attachments. Data were analyzed by Friedman and chi-square tests.

**Results:** Both masticatory performance and satisfaction levels significantly improved after implant treatment. No significant differences were observed between the overdentures with ball and bar attachments. However, the masticatory performance after treatment was still significantly lower than the performance of the healthy subjects.

**Conclusion:** The rehabilitation of edentulous patients with overdenture with ball or bar-clip attachment improves both satisfaction and masticatory performance, but the outcomes levels are not equal as those found for dentate subjects.

**Key words:** Denture; dental prosthesis; implant-supported; patient satisfaction; mastication; masticatory performance

### Resumo

**Objetivo:** Comparar o nível de satisfação e a performance mastigatória dos indivíduos com dentição normal e pacientes reabilitados com uma sobredentadura suportada por implantes com dois tipos de conectores diferentes, sistema de retenção bola e barra.

**Metodologia:** Vinte e quatro indivíduos participaram do estudo, sendo 12 pacientes desdentados e 12 indivíduos dentados totais. Os desdentados receberam dois implantes e novas dentaduras, superiores e inferiores. Três meses depois da primeira fase cirúrgica, a dentadura inferior foi conectada aos implantes através do sistema bola. Dois meses depois, uma nova sobredentadura inferior foi realizada, porém desta vez conectado através do sistema barra-clipe. O nível de satisfação (OHIP-EDENT adaptado e escala verbal de medição) e a performance mastigatória (mastigação por 40 ciclos mastigatórios) foram medidas em vários momentos do tratamento, com as dentaduras antigas, novas não conectadas por implantes, e depois de ter conectado a sobredentadura pelo sistema bola e barra-clipe. O teste de Friedman e o teste qui-quadrado foram aplicados para analisar os resultados.

**Resultados:** O nível de satisfação e a performance mastigatória melhoraram significativamente após a reabilitação com os implantes. Nenhuma diferença foi observada entre as sobredentaduras com sistema bola e barra-clipe. Entretanto, a performance mastigatória ainda permaneceu significativamente menor que a performance dos indivíduos dentados.

**Conclusão:** A reabilitação de pacientes edêntulos reabilitados com sobredentadura com bola ou barra-clipe melhora tanto o nível de satisfação, quanto a performance mastigatória, porém ainda abaixo do nível dos indivíduos com dentição normal.

**Palavras-chave:** Dentadura; prótese dentária; implantossuportada; satisfação do paciente; performance mastigatória

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## Introduction

The rehabilitation of edentulous patients is one of the main challenges in Dentistry, especially for the mandibular arch. For more than a hundred years, conventional dentures were the best treatment available for this condition, but many patients remained dissatisfied and still had problems related with their oral function. This was caused by retention and stability problems of the mandibular dentures (1,2). Complete-dentures wearers frequently have problems with their old full dentures, and 5 to 20% are dissatisfied after the treatment with new conventional dentures (3).

Besides retention and stability problems, masticatory function in subjects with conventional dentures can be poor in comparison with healthy dentate subjects (4,5). The masticatory performance is reduced to one-fourth to one-seventh of the performance of dentate subjects, depending on age and type of food (6,7). Thus, denture wearers need seven times more masticatory cycles to reduce food to half of its original size (4).

Nowadays, with the possibility of oral rehabilitation with mandibular implant retained overdentures, the satisfaction level and masticatory function have been improved (2,8-11). It was reported that after stabilization of the mandibular denture with two osseointegrated implants the maximum bite force doubled, whereas the number of chewing cycles needed to comminute food particles to a certain size became half of that before implant treatment (2). Furthermore, mandibular implant-supported overdenture treatment reduced various denture complaints (8). The most common systems used to retain overdentures are ball and bar-clip attachments. Ball attachments may be less expensive and technique-sensitive and more adequate to tapered arches, but they seem to be less retentive than bar-clip attachments and need more maintenance, especially in the first year (11,12).

The aim of this study was to compare the masticatory performance and satisfaction levels of subjects with natural dentition with edentate patients rehabilitated with a new denture and after implant treatment with two different attachments (ball and bar-clip retention systems). The satisfaction levels were measured with questionnaires adapted from the OHIP-EDENT index. The *a priori* hypothesis was that implant treatment improves masticatory performance and satisfaction levels.

## Materials and Methods

### Subjects

Twenty-four subjects were selected for this study; 12 were dentate subjects and 12 were edentulous patients and complete dentures wearers for more than 5 years. The patients were not satisfied with their full dentures and voluntarily searched for the oral rehabilitation services provided by the Department of Prosthodontics and Oral-maxillofacial Surgery, at the Dental School of the Lutheran University of Brazil, Canoas, RS, Brazil. For the edentulous group, the inclusion criteria were: patients were fully edentulous,

used conventional removable full dentures for at least 5 years, and had sufficient bone height and thickness for the insertion of two osseointegrated implants in the mandibular anterior region between the mental foramina (confirmed by panoramic radiographs, ranging from 10 to 15 mm high). The exclusion criteria were: presence of temporomandibular disorder, bruxism, systemic and/or neurological disorders, and smoking habits. The edentulous group consisted of 2 males and 10 females with a mean age of  $61 \pm 4.6$  years.

The dentate subjects were recruited through advertisement in the Lutheran University of Brazil. Only healthy subjects with 28 teeth, without any restorations, and with normal occlusion were included. This group consisted of 5 males and 7 females with a mean age of  $26 \pm 3.3$  year-old.

The study was approved by the Ethics Committee of the University (protocol 2004-391H), and the subjects signed an informed consent before the research procedures.

### Surgical and Prosthetics Procedures

The patients received two osseointegrated implants (Replace® Select Tapered; Nobel Biocare™; Gothenburg, Sweden; diameter of 3.5 or 4.3 mm; length of 10 or 13 mm), which were placed between the mental foramina according to a standardized two-stage surgical protocol. New conventional full dentures in the maxilla and mandible were made one month after the first-stage surgery, following the healing of the soft tissues. The new dentures were manufactured according to the following protocol: balanced bilateral occlusion, centric relation position, with Trilux acrylic teeth (Ruthibras, Pirassununga, Brazil) with a 33 angle degree of the cusps; selection of gingival color by the Tomáz Gomes scale (Vipi, Pirassununga, Brazil), and palate in colorless acrylic. In each quadrant, 2 bicuspids and 1 molar were used. Patients started to use their new dentures without any attachments, 2 months after the first surgical step, during a three-month period. The second-stage surgery was done 5 months after the implantation. Two small incisions were done to expose the head of the screws, and 2 or 3 mm high ball attachments (Ball Attachment®; Nobel Biocare™; Gothenburg, Sweden) were placed with a 15 N torque. The lower denture was connected to the ball attachments by means of a gold cap (Nobel Biocare™; Gothenburg, Sweden).

Two months later, new mandibular overdentures were made and the overdentures were then connected to the implants by a bar-clip attachment. The ball attachments were removed and pick-up impression posts were placed at the implant level. An impression was taken with a rigid impression material (Impregum™, 3M ESPE, Germany). From this impression, a cast was poured and from this cast the bar-clip attachment was made using gold bar abutments (Gold Abutment Bar®; Nobel Biocare™; Gothenburg, Sweden) and a plastic bar (Sterngold ImplaMed, Stockholm, Sweden). The manufacturing of the new overdenture followed the same protocol and had the same characteristics as the first one.

## Experimental Design

Masticatory performance measurements were performed with the edentulous patients at four distinct moments: with the old conventional dentures, after 45-60 days of using the new conventional dentures and with the overdentures with the ball and the bar-clip attachment. The overdenture was used during 45 days. The chewing tests were performed twice with an interval of two hours to avoid muscle fatigue. The results of the two tests were averaged. The satisfaction levels of the patients were measured at the four different moments described. Masticatory performance was also obtained from the dentate subjects.

## Artificial Test Material

The chewing test material was Optocal – Brazilian Version (Optocal-BV), that consists of 58.3% Optosil (Condensing Silicon; Heraeus Kulzer GmbH & Co. Sao Paulo, Brazil), 7.5% conventional tooth paste (Colgate-Palmolive Co. Sao Paulo, Brazil), 11.5% solid vaseline, 10.2% of dental plaster (Mossoró®, Sao Paulo, Brazil), 12,5% alginate powder (Jeltrate – Dentsply Ind. & Com. Ltda, Sao Paulo, Brazil) (2,4,5) and 3 drops of mint essence, mixed with 20.8 mg/g of the catalyst paste. This test food was prepared so that all edentulous patients, users of conventional full dentures, could chew the food without major problems due to the material hardness. After mixing the components according to the manufacturer's recommendations, the mixture was placed on a mould with 600 orifices of 5 mm-thick and 12 mm-diameter. The resulting tablets were left in a closed container with silica to remove the humidity until total drying (13).

## Masticatory Performance

The masticatory performance of all patients was measured by having the patients chew on 12 tablets of Optocal-BV with a total volume of approximately 3 cm<sup>3</sup>. The patients chewed the Optocal-BV for 40 chewing strokes, trying not to swallow any fragments. After chewing the particles were spat out, collected, washed, and dried. The test food was weighed before and after the tests in order to determine the amount of material lost. The degree of fragmentation of the test food was determined by sieving the chewed food through a stack of 5 sieves with apertures from 4.5 to 1 mm and a bottom plate. The amount of Optocal-BV on each sieve was then weighted. The masticatory performance was determined with the so-called Rosin-Rammler equation:  $Q_w = 100[1 - 2^{-(x/x_{50})^b}]$  (13-15). The degree of fragmentation of the test food (masticatory performance) is given by the median particle size,  $X_{50}$ , which is the aperture of a theoretical sieve through which 50% of the weight of the comminuted food could pass.

## Satisfaction Level

The satisfaction levels were evaluated by means of a questionnaire (Fig. 1) adapted from Oral Health Impact

Profile for Edentulous Patient (OHIP-EDENT) (8,16). Individuals were invited to express their opinions about the condition of their dentures through nine questions of the questionnaire I, in a scale ranging from 0 (zero) to 4 (four), where 0 represents total satisfaction and 4 total dissatisfaction. The highest scores of the questionnaire I represent the worst satisfaction level and masticatory ability. For questionnaire I the maximum score was 36. Satisfaction level was calculated from the scores of the questionnaire, such that the highest score (worst satisfaction) was 0% and the lowest score was 100%. A higher percentage thus represents a better satisfaction level. After filling out the questionnaire, the patients also were asked to give a score from 0 to 10 by verbal rating scale (VRS) to their satisfaction level (Fig. 2).

| Questions |   | 0                     | 1                     | 2                     | 3                     | 4                     |
|-----------|---|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| 1         | How do you feel about the pleasure you get from food, compared with the time when you had natural teeth?  | <input type="radio"/> |
| 2         | With respect to chewing, how satisfied are you with your dentures?  | <input type="radio"/> |
| 3         | With respect to appearance, how satisfied are you with your dentures?                                     | <input type="radio"/> |
| 4         | With respect to how comfortable your dentures are, how satisfied are you?                                 | <input type="radio"/> |
| 5         | With respect to being self-assured and self-conscious, how satisfied are you with your dentures?          | <input type="radio"/> |
| 6         | With respect to your social and affective relationships, how satisfied are you with your oral conditions? | <input type="radio"/> |
| 7         | With respect to your professional performance, how satisfied are you with your oral conditions?           | <input type="radio"/> |
| 8         | With respect to eating, how satisfied are you with your dentures?   | <input type="radio"/> |
| 9         | Are you satisfied with your smile (esthetics)?  | <input type="radio"/> |

Fig. 1. Questionnaire I: Questions about satisfaction level.

|  |
|--|
| <p>Considering the quality offered by your dentures (comfort, self-assurance and esthetics or appearance), please give a classification from 0 (very bad) to 10 (excellent) of your general satisfaction level in relation to your oral conditions.</p> <p>Classification: _____</p> |
|--|

Fig. 2. Verbal Rating Scale (VRS) to record general satisfaction level.

## Statistical Analysis

Descriptive statistics (percentages, median, mean values and standard deviation) were calculated. The normality of data was analyzed by the Kolmogorov-Smirnov test, and the non-parametric Friedman test was applied for pairwise comparisons of the outcomes satisfaction level and masticatory performance evaluating the differences

in individual questions of the questionnaires and the VRS scores. The chi-square test was used to test the differences in proportions for the type of attachment preference. The association between masticatory performance and satisfaction level was calculated with the Pearson correlation test. Data analysis was performed by using the SPSS 15.0 statistical software (SPSS, Inc., Chicago, IL, USA), with a significance level of 5%.

## Results

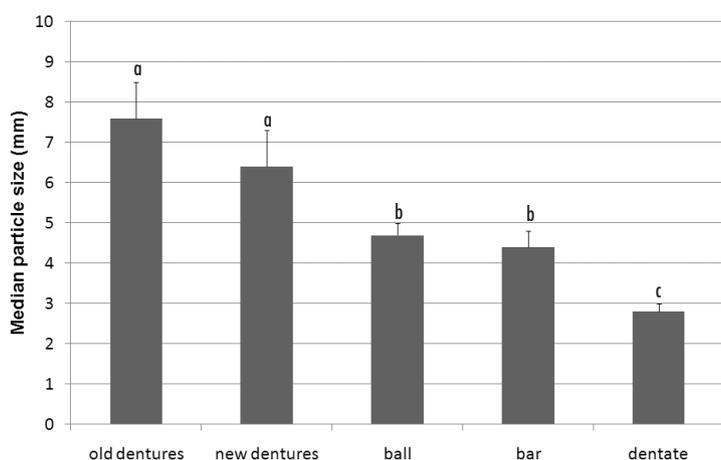
### Masticatory performance

Significant differences in masticatory performance were found between the dentate subjects and the denture patients at all four measuring moments ( $P=0.001$ ). After 40 chewing strokes, the dentate subjects reduced the test food from 12 to 2.69 mm (SD 0.43 mm) in particle size. The figures for the edentulous patients were: with the old dentures from

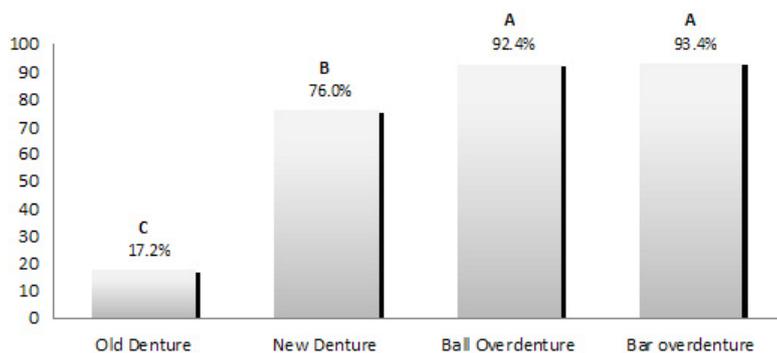
12 to 7.50 mm (SD 2.68 mm), with the new unattached denture from 12 to 6.47 mm (SD 2.84 mm), with the ball overdenture from 12 to 4.52 mm (SD 1.05 mm), and with the bar-clip overdenture from 12 to 4.30 mm (SD 1.17 mm) (Fig. 3).

### Satisfaction level

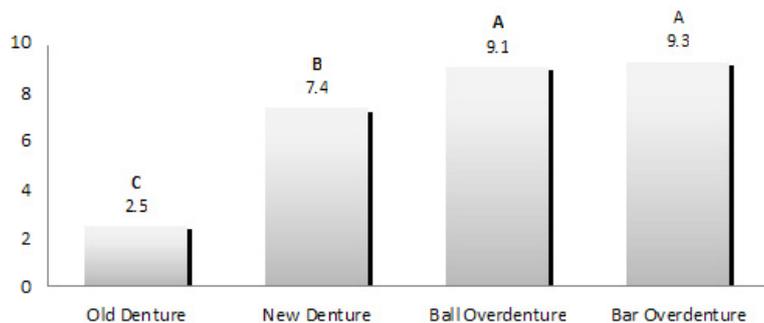
The subjects with the old full dentures had a significantly lower satisfaction level (17.2%,  $P<0.05$ ) than with the new dentures (76%). The satisfaction levels with overdentures were significantly higher than with the new dentures (92.4% for ball attachment and 93.4% for bar-clip attachment) (Fig. 4). These findings are in agreement with the evaluation by VRS, as the mean VRS scores for the general satisfaction level increased significantly from the old denture treatment to the overdenture treatment modalities (from 2.5 to 9.3). Ball and bar-clip attachments did not show any statistical differences in satisfaction levels (Fig. 5).



**Fig. 3.** Average median particle size and standard error of the mean (SEM) after 40 chewing cycles for the five different groups ( $n=12$ ). Smaller median particle sizes indicate better food fragmentation and thus better masticatory performance. Bars with different letters are significantly different ( $P<0.05$ ).



**Fig. 4.** Comparison of satisfaction level (%) among treatment modalities. Bars with different letters are significantly different ( $P<0.05$ ).



**Fig. 5.** Comparison of general satisfaction level (VRS scores). Bars with different letters are significantly different ( $P<0.05$ ).

**Table 1.** Median and mean ( $\pm$  standard deviation) scale scores for the individual questions about satisfaction level and differences among treatment modalities.

| Question |               | Old (1)         | New (2)         | Ball (3)        | Bar (4)         | P value* | Contrasts <sup>†</sup> |     |     |
|----------|---------------|-----------------|-----------------|-----------------|-----------------|----------|------------------------|-----|-----|
| 1        | Median        | 4.00            | 1.00            | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.55 $\pm$ 0.82 | 1.27 $\pm$ 0.91 | 0.55 $\pm$ 0.69 | 0.36 $\pm$ 0.51 | <0.0001  | 3<1                    | 4<1 |     |
| 2        | Median        | 4.00            | 1.00            | 1.00            | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.46 $\pm$ 0.69 | 1.27 $\pm$ 0.79 | 0.55 $\pm$ 0.52 | 0.36 $\pm$ 0.51 | <0.0001  | 3<1                    | 4<1 |     |
| 3        | Median        | 4.00            | 0               | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.27 $\pm$ 1.19 | 0.55 $\pm$ 1.21 | 0.18 $\pm$ 0.41 | 0.09 $\pm$ 0.30 | 0.0004   | 3<1                    | 4<1 | 2<1 |
| 4        | Median        | 4.00            | 1.00            | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.46 $\pm$ 0.93 | 1.09 $\pm$ 0.94 | 0.18 $\pm$ 0.41 | 0.09 $\pm$ 0.30 | <0.0001  | 3<1                    | 4<1 |     |
| 5        | Median        | 4.00            | 1.00            | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.36 $\pm$ 0.92 | 0.91 $\pm$ 0.94 | 0.36 $\pm$ 0.67 | 0.09 $\pm$ 0.30 | 0.0001   | 3<1                    | 4<1 |     |
| 6        | Median        | 3.00            | 1.00            | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.00 $\pm$ 0.89 | 0.64 $\pm$ 0.67 | 0.09 $\pm$ 0.30 | 0.36 $\pm$ 0.50 | <0.0001  | 3<1                    | 4<1 | 2<1 |
| 7        | Median        | 3.00            | 1.00            | 1.00            | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.00 $\pm$ 1.10 | 0.64 $\pm$ 0.67 | 0.64 $\pm$ 0.67 | 0.36 $\pm$ 0.50 | 0.0004   | 3<1                    | 4<1 | 2<1 |
| 8        | Median        | 3.00            | 1.00            | 1.00            | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.45 $\pm$ 0.52 | 1.45 $\pm$ 1.04 | 0.55 $\pm$ 0.52 | 0.36 $\pm$ 0.50 | <0.0001  | 3<1                    | 4<1 |     |
| 9        | Median        | 4.00            | 0               | 0               | 0               |          |                        |     |     |
|          | Mean $\pm$ SD | 3.27 $\pm$ 1.01 | 0.73 $\pm$ 1.27 | 0.18 $\pm$ 0.40 | 0.27 $\pm$ 0.47 | 0.0002   | 3<1                    | 4<1 | 2<1 |

\* Friedman test

† P&lt;0.01

The analysis of individual questions showed also higher satisfaction levels with both overdenture types than with the old dentures (Table 1). The results of the questions about appearance satisfaction (questions 3, 6, 7 and 9) showed a significant increase with the new dentures in comparison with the old ones. No increase in satisfaction was found for questions related to eating, chewing, and denture stability. The Pearson correlation coefficients between the satisfaction scores and performance masticatory were all low and statistically non-significant.

## Discussion

Masticatory performance is the outcome of complex simultaneous interrelationships among physiological and contextual variables (17). Dentate subjects with natural dentition were compared with edentulous patients rehabilitated with overdentures. The median particle size obtained after 40 chewing strokes is a measure of the masticatory performance: a smaller particle size, thus lower  $X_{50}$  values, indicates a better masticatory performance (18). In contrast to longitudinal study designs (5), in the present study the patients had the opportunity to experience all treatment modalities: old denture, new denture, overdenture with ball attachment, and overdenture with bar-clip attachment. Thus, it was possible to compare the different treatment results within-subjects and find out which treatment had the best effect on masticatory performance. Furthermore, the study design enabled the comparison of results after implant treatment with masticatory performance of dentate subjects, which is considered the gold standard. The present findings showed that subjects with natural dentition pulverized the particles of the Optocal-BV into smaller pieces than the

patients before and after treatment. Previous studies reported that denture wearers had only 14 to 25% of the masticatory performance of dentate subjects depending on the age and the type of food (4,5,19). After implant treatment with two implants masticatory performance improved to 4.3 mm ( $X_{50}$  values) as compared to the dentate group (2.69 mm). In this study, masticatory tests were performed with an artificial test material called Optocal – Brazilian Version (13). For measurements of masticatory performance, artificial materials are commonly used because they provide good characteristics and are easily reproduced (2,4,14,20). Physical properties of natural foods may vary due to seasonal and geographical influences. Most patients are not familiar with the product and detailed instructions and test training should be applied before the real test (21). The multiple sieves method was used in the present study to obtain a more appropriate average distribution of particles and a more precise determination of the masticatory performance and efficiency, instead of the method of only one sieve (22). Some studies showed that edentulous subjects were more satisfied and had better masticatory performance with new full conventional dentures (8,9). The present results found no statistically significant differences between the old and new dentures, in agreement with other studies (2,23). This may be due to the remaining painful sensitivity at the mucosa above the still submerged implants and/or to a short adaptation period with the dentures (2). Many studies showed that the treatment with implant-retained overdentures improved the patients' masticatory function and satisfaction level (2,5,8,9). After the new overdentures were attached to the implants, the subjects had improved masticatory performance as all patients chewed better and achieved smaller particle sizes after 40 chewing cycles.

The type of attachment did not influence masticatory performance. Both ball and bar-clip attachments allowed significant improvement of the masticatory performance compared with conventional dentures. This is in agreement with results by van Kampen et al. (2) and can be attributed to the fact that both attachment systems improved prostheses retention and stability, so the subjects could chew the food better, in a more natural way and with less pain and restriction.

No significant association was found between the objective (masticatory performance) and subjective (satisfaction level) measurements. Similar results were reported by Cune et al. (9). Thus, patients with better masticatory performance are not necessarily more satisfied. This may be explained by the fact that subjects were very dissatisfied with their old dentures and had serious retention and stability problems. They were not able to chew properly and had pain complaints. After rehabilitation with new conventional dentures patients were much more satisfied, in agreement with results reported by Pocztaruk et al. (8). Satisfaction levels were much higher even before the prostheses had been anchored by implants. This suggests that some patients may experience a treatment placebo effect when they undergo some procedure and may unconsciously feel an improved ability to chew. The higher satisfaction levels obtained with the new conventional dentures can be attributed to better comfort and aesthetics of the dentures, which were manufactured with a higher quality than the old ones. In this way the association between masticatory performance and satisfaction may have been masked. The treatment of edentulous individuals with an overdenture seems to be very efficient in relation to the reduction of problems originated from the conventional dentures (8,9,11,16).

No significant differences in satisfaction level and masticatory performance were detected between the two

attachments types, which concurs with findings of Cune et al. (9). From the comparisons of individual questions, the patients were more satisfied on aesthetics with the new dentures and overdentures than with the old dentures. The bar and ball attachment also caused a significant improvement in chewing, as well as in denture stability. This confirms the efficiency of the retention provided by implants (9,10,12). Nonetheless, the present sample size was relatively small; therefore, data should be interpreted carefully. However, the study population was homogenous due to the strict inclusion criteria and the same group of edentulous patients was analyzed before and after treatment (24). Thus, the present results support the benefits of implant treatment, and patients can be informed how implant treatment will improve their oral function and everyday lives (25). So the rehabilitation with a mandibular overdenture, with ball or bar-clip attachments, improved both masticatory performance and satisfaction in edentulous patients.

## Conclusion

Patients rehabilitated with overdenture retained by ball or bar-clip attachments had significant improvement of masticatory performance compared with the old and new conventional dentures. However, the masticatory performance still was significantly lower than that of fully dentate subjects. Furthermore, implant rehabilitation with ball or bar-clip attachments significantly improved the satisfaction levels of the rehabilitated edentulous patients.

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