Masticatory efficiency and oral health-related quality of life with implant-retained mandibular overdentures

Xu Sun, MD, Jun-Jiang Zhai, MD, Jian Liao, MD, Min-Hua Teng, MD, Ai Tian, MD, Xing Liang, DDS, MD.

ABSTRACT

Objectives: To evaluate masticatory efficiency (ME) and oral health-related quality of life (OHRQoL) in patients rehabilitated with implant-retained mandibular overdentures.

Methods: In this randomized controlled clinical trial, 50 edentulous patients visiting the Implant Center and Department of Prosthodontics, West China College of Stomatology, Sichuan University, Chengdu, China between June 2010 and June 2012 were selected and received 2 implant-retained mandibular overdenture treatments. All patients were rehabilitated with maxillary complete dentures. The ME and OHRQoL were determined both one month before the mandibular complete denture was anchored to the osseointegrated implants, and 6 months after anchoring. Paired t-tests were used to compare means of ME, and oral health impact profile-49 (OHIP-49) domains scores between pre- and post-implant. Linear regression models were utilized to seek correlations between ME and OHIP domains scores.

Results: The ME increased from pre- to post-implant retained mandibular overdentures significantly (p<0.001). The total OHIP score and 4 subscales scores were changed significantly from pre- to post-implant; namely, functional limitation, psychological discomfort, physical disability, and physical pain. The total OHIP score, functional limitation, physical disability, and physical pain subscale scores were related to ME.

Conclusion: Implant-retained mandibular overdentures can significantly improve patients' ME and OHRQoL. The improvement in OHRQoL is mainly because of the improved ME. An improved chewing experience, and pain relief also contributes to improvement of OHRQoL.
For mandibular edentulous patients, conventional complete dentures are not always ideal, although the conventional complete denture procedure is simple, appointment times, and costs less. Many patients are not satisfied with the clinical effects of conventional complete dentures, due to handicaps in eating and speaking, uncomfortable, poor retention, and stability. An implant-retained complete denture can solve many of the above-mentioned problems and satisfy these patients. Compared with conventional complete dentures, implant-retained complete dentures have many advantages such as excellent retention, ease of use, and good aesthetics. Masticatory efficiency (ME) with conventional complete denture is almost 30% of natural dentition. Thus, as the most important oral function, the ME needs to be improved by implant-retained mandibular overdentures. Many investigators have conducted research, and the results suggest that ME improved substantially after implants are used. Patient-centered standards of oral health-related quality of life (OHRQoL) has also been increasingly emphasized in many studies. Restoration success was found to be largely affected by the patient’s point of view, as they feel more subjectively regarding prosthesis stability, comfort, chewing performance, language, and so forth. Compared with conventional complete dentures, 2-implant retained overdentures, as the standard treatment option for mandibular edentulous patients, has lead to a better level of OHRQoL. It is well known that OHRQoL is influenced by many factors, such as the patient’s gender, age, the number of implants, attachment type, level of education, cultural differences, and socio-economic environment, all of which are fixed pre-implant parameters and immutable. The role of improved ME in patients with implant-retained mandibular overdentures on improvement in OHRQoL should be detected. The objective of this randomized controlled clinical study was to evaluate ME and OHRQoL in patients rehabilitated with implant-retained mandibular overdentures. In this research, the correlation between improvement of ME and improvement of OHRQoL from pre- to post-implant was also investigated. These findings may be helpful in clinical decision-making regarding implant-retained overdenture options for mandibular edentulous patients.

Methods. A randomized controlled clinical trial was performed in the Department of Prosthodontics, West China College of Stomatology, Sichuan University, Chengdu, China. Patients visiting the West China College of Stomatology account for one-third of the Chinese population, and can therefore be considered representative.

Subjects were selected from mandibular edentulous patients attending the Implant Center and Department of Prosthodontics, West China College of Stomatology, Sichuan University between June 2010 and June 2012 according to the following criteria. Inclusion criteria: 1) age between 55 and 75 years; 2) wearing maxillary and mandibular complete dentures for at least 5 years; 3) willingness to change from the old complete denture; 4) willingness to choose implant-retained mandibular over denture; 5) ability to attend for follow up.

The study was approved by the Research Ethics Committee of Sichuan University, and met the requirements of the Declaration of Helsinki (1989) for prospective clinical studies with humans (informed consent principle). A new pair of complete dentures was fabricated for each patient. The new dentures were made with semi-anatomically shaped acrylic teeth (Huge Company, Shanghai, China). One month after complete denture delivery, 2 International Team for Implantology (ITI) implants (Strauman Company, Waldenburg, Switzerland) for each subject were placed between the mental foramina, according to a standardized 2-stage surgical protocol. To minimize loading of the implants during the osseointegration period, the tissue surface of the complete denture base corresponding to the implants was ground. Six months after implantation, the second stage of surgery was performed, and abutments were applied. If the interval between the maxillary and mandibular was sufficient enough to accommodate LOCATOR stud attachments, a pair of LOCATOR stud attachments (Straumann Company, City, Switzerland) were applied to anchor the mandibular complete denture, otherwise...
dental magnetic attachments (Aichi Steel Corp., Tokai, Japan) were applied. After a relining procedure for the intaglio surface of the mandibular denture with self-curing acrylic resin as a final restoration, patients were given instructions on care of the implant-retained overdentures and attachments.

**Evaluation.** For each subject, the ME, and OHRQoL were determined both one month before the mandibular complete dentures were anchored to the osseointegrated implants, and 6 months after they had been anchored. The ME was evaluated using the gravimetric method. The subjects were instructed to chew test food (4g of peanuts) normally for 20 seconds. The peanuts used in this test were dried and of uniform size. The chewed peanuts were expectorated in a cup, and the mouth thoroughly rinsed twice with water (15 ml). The rinsing was added to the cup to recover all the test food. The whole content of the cup was poured onto a 20-mesh US standard sieve. Fine particles were washed through the sieve with a jet of water. The content of the sieve was dried in an oven and weighed at an electronic balance to get the weight ‘m’. The ME of the patient was ME (ME= 4/m - 4 × 100%). This test was repeated 3 times. The OHRQoL was evaluated using the 49-item version of the Oral Health Impact Profile (OHIP-49). The OHIP-49 is the most standard and validated questionnaire for measuring OHRQoL, and includes 7 domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. The OHIP-49 was translated into Chinese and applied with face-to-face interviews by just one interviewer. Intra-class reliability, test/re-test reliability, and validity were previously evaluated by Slade and Spencer, with an intra-class correlation coefficient (ICC) of >0.75. Every item was scaled using a 5-point scale: never = 0, rarely = 1, occasionally = 2, often = 3, very often = 4. The total scores were calculated by adding the 49 items scores and ranged between 0 and 196, with lower scores indicating better OHRQoL. Every domain score of this questionnaire was also calculated.

**Statistical analyses.** All data were analyzed using the Statistical Package for Social Sciences version 13.0 (SPSS Inc., Chicago, IL, USA). Paired t-tests were used to compare pre- and post-implant ME, OHIP-49 total scores, and every domain score. A level of $p<0.05$ was considered significant, exact $p$ values and confidence intervals (CI) were used. Effect sizes (ES) were estimated using a procedure recommended by Kazis et al to show the size of the change from pre- to post-implant. Effect size can be expressed mathematically as $ES = (m_1 - m_2)/SD$, where $m_1$ is the pre-implant mean, $m_2$ the post-implant mean, and SD, the pre-implant standard deviation. Effect size can be used to translate changes in ME and OHIP into a standard unit of measurement that will provide a clearer interpretation of the results. Cohen defined an effect size of $<0.50$ as small, one of $0.50-0.80$ as moderate, and one of $>0.80$ as large. Linear regression models were used to seek correlations between ME and OHIP total scores, and OHIP domains scores. Pearson coefficients of correlation and confidence intervals were used to analyze the strength of haphazard correlations between change of ME and changes of OHIP total scores, and OHIP domains scores. Linear regression models were used to seek the contributions of the confounders (age, gender, living state, education level, and income) on a decrease in OHIP-49 total scores.

**Results.** Table 1 summarizes the baseline information for 50 patients (28 men and 22 women, aged between 55 and 74 years; mean 62 years) enrolled in the study. In Table 2 indicates that the ME of all subjects in this study increased from pre- to post-implant. The mean difference was 15.17%, which was statistically significant. One subject data was not recorded, as patient contact was lost. Table 3 demonstrates that the total OHIP scores, and 4 OHIP subscales scores were changed significantly in all 7 OHIP domains scores. The ES of OHIP subscales scores were favorable and exceeded the threshold value of 0.5 for functional

| Table 1 - Socio-demographic characteristics of 50 patients. |
|-------------------------------------------------------------|
| **Characteristics** | **n (%)** |
| **Age (years)** | |
| 60.0-65.9 | 22 (44) |
| 66.0-70.0 | 28 (56) |
| **Gender** | |
| Female | 22 (44) |
| Male | 28 (56) |
| **Living status** | |
| Alone | 4 (8) |
| With family/others | 45 (90) |
| No answer | 1 (2) |
| **Education level** | |
| Elementary/High school | 35 (70) |
| College | 12 (24) |
| No answer | 3 (6) |
| **Income (RMB)** | |
| <2,000 | 25 (50) |
| ≥2,000 | 15 (30) |
| No answer | 10 (20) |

RMB - Renminbi
Effect of implant mandibular overdentures ... Sun et al

Table 4 - Correlation between decrease in Oral Health Impact Profile (OHIP-49) subscale scores and increase in masticatory efficiency (ME).

| Independent variable (variation in) | Dependant variable (variation in) | R² | β     | P-value | 95% confidence intervals |
|------------------------------------|-----------------------------------|----|-------|---------|-------------------------|
| Mean of ME                         |                                    |    |       |         |                         |
| Functional limitation              | 0.807                             | 0.056 | 0.000 | 0.0615, 0.921           |
| Physical pain                      | 0.304                             | 0.002 | 0.000 | 0.015, 0.407            |
| Psychological discomfort           | 0.097                             | 0.001 | 0.351 | -0.732, 0.290           |
| Physical disability                | 0.709                             | 0.032 | 0.001 | 0.439, 1.871            |
| Psychological disability           | 0.000                             | 0.041 | 0.986 | -0.003, 0.729           |
| Social disability                  | 0.003                             | 0.039 | 0.901 | -0.183, 0.489           |
| Handicap                           | 0.007                             | 0.036 | 0.583 | -0.236, 0.415           |
| Total OHIP scores                  | 0.624                             | 0.030 | 0.000 | 0.219, 1.674            |

Discussion. Masticatory efficiency (ME) can exactly reflect a patient's masticatory function. In agreement with the findings of numerous studies, the ME of all 49 patients increased significantly from pre-implant to post-implant anchor of the complete denture to the mandibular in this study. The retention and stability of the implant-retained mandibular complete denture mainly depend on attachments. The improvement of ME from pre- to post-implantation is mainly because of the improved stability and retention of the complete denture, which also makes the patients feel more comfortable, and easily adapt to the new denture. The width of the chewing cycle affected ME more than the height, mainly during lateral movement. It is reported that muscle activity is not significantly affected by different attachment types, in van der Bilt's research, 18 patients received 2 implants-retained mandibular overdentures with 3 different attachment modalities: a magnet, a ball, and a bar-clip attachment. Patients' satisfaction was also reported to not be affected by the change of ME. Table 5 demonstrates that socio demographic characteristics were not significantly associated with a decrease in OHIP total scores. All the confounders were not positively associated with a decrease in OHIP total scores (R²=0.007).

Table 2 - The masticatory efficiency of all subjects increased from pre- to post-implant.

| Masticatory efficiency | N | Means±SD |
|------------------------|---|----------|
| Pre-implant            | 50 | 47.41±7.23 |
| Post-implant           | 49* | 62.58±6.64 |
| Difference             | 49* | 15.17±10.19 |
| P-value                | 0.000 |

*one data was not included

Table 3 - Mean of oral health impact profile (OHIP-49) subscales scores, and effect size (n=50).

| OHIP subscale            | Pre-implant | Post-implant | Difference | Paired t-test | P-value | ES |
|-------------------------|-------------|--------------|------------|---------------|---------|----|
| Functional limitation   | 22.4±4.2    | 11.7±5.1     | 10.6±9.4   | 8.92          | 0.000   | 1.3|
| Physical pain           | 12.9±4.3    | 10.6±3.2     | 2.1±5.6    | 5.15          | 0.000   | 0.5|
| Psychological discomfort | 10.1±4.1    | 6.8±3.9      | 4.9±5.2    | 6.87          | 0.000   | 1.2|
| Physical disability     | 8.5±3.8     | 5.1±3.4      | 3.4±4.6    | 5.15          | 0.000   | 0.9|
| Psychological disability| 4.9±2.8     | 3.7±2.1      | 0.84±2.8   | 1.83          | 0.071   | 0.3|
| Social disability       | 5.0±2.3     | 4.6±1.7      | 0.92±2.1   | 1.91          | 0.052   | 0.4|
| Handicap                | 4.8±2.7     | 3.5±2.6      | 1.08±3.9   | 1.84          | 0.069   | 0.3|
| Total OHIP scores       | 59.6±14.7   | 39.3±14.7    | 20.6±28.2  | 5.33          | 0.000   | 0.8|
Effect of implant mandibular overdentures ... Sun et al

by different attachment styles. A recent systematic review by Kim et al indicated that the treatment effect with mandibular implant overdenture is not related to attachment system. Thus, the 2 different attachment systems, locator attachment and magnetic attachment, will not influence the results of this study.

In addition to the improvement in ME, a good complete denture can greatly improve the OHRQoL of patients, even though the OHRQoL is a more comprehensive criterion for an edentulous patient. Thus, the evaluation of a restoration’s effect on OHRQoL of patients increased recently. In this study, from pre- to post-implant, we found that the average of OHIP total scores reduced from 59.6±25.2 to 39.3±14.7, and reduced by an average of 20.6±28.2 (p<0.001), which indicated that the OHRQoL of patients was significantly improved.

This result was similar to Awad et al, who performed an international multicenter study, including 8 centers in North America, South America, and Europe. Their conclusion is that mandibular 2-implant overdentures are more likely than conventional dentures to improve OHRQoL for edentulous patients. The recent review analysis by Thomason illustrated that patient OHRQoL is greater with mandibular implant-retained overdentures than conventional dentures; nevertheless, the magnitude of these effects remains uncertain, and heterogeneity of outcomes was observed. An uncertain intensity of effect maybe due to the different characteristics of the population many researchers investigated, and different versions of the OHIP researchers chose, which made the comparisons between studies very difficult. The OHIP-49, was the standard to measure OHRQoL with highest level of reliability and validity, from which other versions evolved for simplicity and convenience applications, such as OHIP-EDENT (Oral Health Impact Profile in edentulous adults) questionnaire, OHIP-14, and OHIP-20. Although the responsiveness of the 49-item OHIP could be maintained with fewer item versions of OHIP questionnaires, this will lead to compromises in reliability and validity. The Chinese version of the OHIP-14 was not tested and verified with the original OHIP-49. We used the translated OHIP-49 in this study, regardless of the fact that this was time consuming and very difficult to analyze.

Seven domains of the OHIP-49 all changed significantly except “psychological disability,” “social disability,” and “handicap”. It can be stated that a mandibular complete denture has little effect on the social function and handicap in the elderly population. The scores at pre-implant in these domains were so low that there is no room for improvement. Preciado et al also reported that 100% of patients in his study reported no impact for the “social disability” and “handicap” domains. While, the present study also found no effect of implant overdentures on “psychological disability” domain, this maybe because there are international and cultural differences between different populations investigated. The word “disability” has a vague definition in Chinese, which usually refers to severe dysfunction. So the options in “psychological disability” domain may not be understand properly by Chinese patients.

In this study, the effect of implant-retained overdentures on “function limitation (ES=1.3),”

Table 5 - Correlation between sociodemographic characteristics and decrease in oral health impact profile (OHIP-49) total scores.

| Independent variable | R² | ß   | P-value | 95% confidence intervals |
|----------------------|----|-----|---------|-------------------------|
| Age (years)          |    |     |         |                         |
| <66                  | 0.001 | 0.029 | 0.990 | -2.529, 1.098          |
| >66                  |     |     |         |                         |
| Gender               |    |     |         |                         |
| Female               | 0.000 | 0.043 | 0.981 | -2.051, 0.909          |
| Male                 |     |     |         |                         |
| Living status        |    |     |         |                         |
| Alone                | 0.002 | 0.039 | 0.948 | -1.810, 0.881          |
| With family/others   |     |     |         |                         |
| Education level      |    |     |         |                         |
| ≤High school         | 0.004 | 0.026 | 0.873 | -1.594, 0.567          |
| College              |     |     |         |                         |
| Income               |    |     |         |                         |
| <2,000 RMB           | 0.000 | 0.045 | 0.923 | -2.619, 1.096          |
| ≥2,000 RMB           |     |     |         |                         |
“psychological discomfort (ES=1.2),” “physical disability
(ES=0.9),” and “physical pain (ES=1.31)” domains
was obvious. These findings were very similar to the
results reported previously by Jabbour,9 namely, the
ES for “functional limitation” was 0.84, “psychological
discomfort” was 0.84, and “physical disability” was
1.02. In his study, the domain with the largest ES was
“physical pain” (ES=0.5), which means that the effect of
implant-retained overdentures on releasing pain more
obvious than that in this study. The differences can be
attribute to subjects in his studies being of the mean
age of 70 years, with reduced adaptive ability, and less
likely to adapt to the traditional complete denture.
While, in this study, the average age of subjects was 62
years old. “Physical pain and physical disability” and
“psychological discomfort and psychological disability”
are 2 subscales in the OHIP-49 questionnaire, and
there may be a multi-collinearity relationship between
them from the view of items in each subscale. However,
a discussion of whether subscales in a questionnaire
have a multi-collinearity relationship does not make
sense, because the reliability of the questionnaire has
been previously confirmed.17

In the present study, ME and OHRQoL were
determined just 6 months after the mandibular
overdentures were anchored to the osseointegrated
implants. Such a short-term improvement on OHRQoL was also found by Awad et al,32 who performed a randomized controlled clinical trial with
results suggesting that implant treatment provides
significant short-term improvement on all subscales
of OHRQoL. Although the 49-item version of OHIP
was used in Awad et al’s study,32 the samples in the
study ranged between the ages of 35-65 and the length
of study was not reported. Jabbour9 reported that the
effect of 2 implant-retained mandibular overdentures
on OHRQoL is stable over a 2-year period.

The correlation analysis revealed that improvement
in ME correlated with a decrease in OHIP scores and
R²=0.624, which means 62% of the improvement of
OHRQoL can be explained by the improvement of ME.
The 80% of change in “function limitation,” and 70%
or change in “physical disability” can be explained by
the improvement of ME. It is suggested that implant-
retained mandibular overdenture improved patients’
OHRQoL, and the contribution of improvement in
ME is in prominent aspect.15 The objective results of this
study confirm the conclusion from Knipfer’s research,15
which was on implant function for improving OHRQoL
in elderly patients; mastication and food intake as well
as freedom from pain, might play a prominent role. In
this study, only 30% of the “physical pain” relief can be
explained by the improvement in ME. The stabilizing
effect from implant of mandibular complete dentures
on the reduction of pain may be more significant.
Research by Emami et al29 illustrated that patients with
implant retained mandibular complete dentures who
perceived no rotational movement were more satisfied
with their complete dentures than those who perceived
rotation.

The improvement for “psychological discomfort”
domain does not have any correlation with the
improvement of ME, although the score in
“psychological discomfort” changed largely from pre-
to post-implant (ES=1.2). The results can be explained
by the study of Farias Neto et al,7 which indicated that
implant-retained mandibular overdentures significantly
improved chewing experience, although no effect
on ME has been observed. The improved chewing
experience can attribute to the improved stability and
retention of implant-retained mandibular overdentures.
On the other hand, implant dentures evoked a change
in peri-implant mechanoreceptors, and thus may help
spatial control of jaw movements during chewing,33
perception of food flow as well as patients’ interest in
food.

The OHRQoL of patients is not only related to
patients’ chewing function, but also related to patients’
life, work, and psychological status. Awad stated that
for post-treatment OHIP score, most of which
were unchangeable. The present study explored the
correlation between changes in ME and changes in
OHIP scores, which is subjective in determining the
nature of the improvement in quality of life, as well as
being more meaningful for making a sensible decision
to choose the best treatment option for a patient. It will
be more meaningful if the sample size were greater, and additional randomized controlled clinical trials should research how the ME affects OHIP scores.

In conclusion, implant-retained mandibular overdentures can significantly improve patients’ ME and OHRQoL. The improvement in OHRQoL is mainly because of the improved ME, and improved ME particularly ameliorates patients’ functional performance. An improved chewing experience and pain relief also plays a role in the improvement of OHRQoL.

References

1. Hyland R, Ellis J, Thomason M, El-Feky A, Moynihan P. A qualitative study on patient perspectives of how conventional and implant-supported dentures affect eating. J Dent 2009; 37: 718-723.
2. van der Bilt A, van Kampen FM, Cune MS. Masticatory function with mandibular implant-supported overdentures fitted with different attachment types. Eur J Oral Sci 2006; 114; 191-196.
3. Assad AS, Abd El-Dayem MA, Badawy MM. Comparison between mainly mucosa-supported and combined mucosa-implant-supported mandibular overdentures. Implant Dent 2004; 13: 386-394.
4. Emami E, Heydecke G, Rompre PH, de Grandmont P, Feine JS. Impact of implant support for mandibular dentures on satisfaction, oral and general health-related quality of life: a meta-analysis of randomized-controlled trials. Clin Oral Implants Res 2009; 20: 533-544.
5. Sadig W. A comparative in vitro study on the retention and stability of implant-supported overdentures. Quintessence Int 2009; 40: 313-319.
6. Heath MR. The effect of maximum biting force and bone loss upon masticatory function and dietary selection of the elderly. Int Dent J 1982; 32: 345-356.
7. Farias Neto A, Pereira BM, Xitara RL, Germano AR, Ribeiro JA, Mestriner Junior W, et al. The influence of mandibular implant-retained overdentures in masticatory efficiency. Gerodontology 2012; 29: e650-e655.
8. Albaker AM. The oral health-related quality of life in edentulous patients treated with conventional complete dentures. Gerodontology 2013; 30: 61-66.
9. Jabbour Z, Emami E, de Grandmont P, Rompre PH, Feine JS. Is oral health-related quality of life stable following rehabilitation with mandibular two-implant overdentures? Clin Oral Implants Res 2012; 23: 1205-1209.
10. Assunção WG, Barão VA, Delben JA, Gomes EA, Tabata LF. A comparison of patient satisfaction between treatment with conventional complete dentures and overdentures in the elderly: a literature review. Gerodontology 2010; 27: 154-162.
11. Müller F. Interventions for edentate elders--what is the evidence? Gerodontology 2014; 31 Suppl 1: 44-51.
12. Awad MA, Rashid F, Feine JS; Overdenture effectiveness study team consortium. The effect of mandibular 2-implant overdentures on oral health-related quality of life: an international multicentre study. Clin Oral Implants Res 2014; 25: 46-51.
13. Koshino H, Hitai T, Ishijima T, Tsukagoshi H, Ishigami T, Tanaka Y. Quality of life and masticatory function in denture wearers. J Oral Rehabil 2006; 33: 323-329.
14. Fueki K, Yoshida E, Igarashi Y. A structural equation model relating objective and subjective masticatory function and oral health-related quality of life in patients with removable partial dentures. J Oral Rehabil 2011; 38: 86-94.
15. Knipfer C, Riemann M, Bockler T, Noeth E, Schuster M, Sokol B, et al. Speech intelligibility enhancement after maxillary denture treatment and its impact on quality of life. Int J Prosthodont 2014; 27: 61-69.
16. van Kampen F, Cune M, van der Bilt A, Bosman F. Retention and postinsertion maintenance of bar-clip, ball and magnet attachments in mandibular implant overdenture treatment: an in vivo comparison after 3 months of function. Clin Oral Implants Res 2003; 14: 720-726.
17. Slade GD, Spencer AJ. Development and evaluation of the Oral Health Impact Profile. Community Dent Health 1994; 11: 3-11.
18. Locker D. Measuring oral health: a conceptual framework. Community Dent Health 1988; 5: 3-18.
19. Kazis LE, Anderson JJ, Meenan RF. Effect sizes for interpreting changes in health status. Med Care 1989; 27: S178-S189.
20. Cohen J. Statistical power analysis for the behavioral sciences: Psychology Press. United States of America: Lawrence Erlbaum Associates; 1988.
21. Müller F, Hernandez M, Grütter L, Arcalí-Kessler L, Weingart D, Schimmel M. Masseter muscle thickness, chewing efficiency and bite force in edentulous patients with fixed and removable implant-supported prostheses: a cross-sectional multicenter study. Clin Oral Implants Res 2012; 23: 144-150.
22. Liao XL, Pan SX, Feng HL, Kang YF, Peng D. [Effect of early-loaded small diameter implants retained mandibular overdentures on masticatory performance], Beijing Da Xue Xue Bao 2013; 45: 798-802. Chinese.
23. Elysyad MA, Hegazy SA, Hammouda NI, Al-Tonbary GY, Habib AA. Chewing efficiency and electromyographic activity of masseter muscle with three designs of implant-supported mandibular overdentures: a cross-over study. Clin Oral Implants Res 2014; 25: 742-748.
24. Cordaro L, di Torresanto VM, Petricevic N, Jornet PR, Torsello F. Single unit attachments improve peri-implant soft tissue conditions in mandibular overdentures supported by four implants. Clin Oral Implants Res 2013; 24: 536-542.
25. Kim HY, Lee JY, Shin SW, Bryant SR. Attachment systems for mandibular implant overdentures: a systematic review. J Adv Prosthodont 2012; 4: 197-203.
26. Zhai JJ, Wen C, Teng MH, Liang X. Single implant in the mandibular molar region of edentulous patient. Saudi Med J 2011; 34: 963-967.
27. Thomason JM. The use of mandibular implant-retained overdentures improve patient satisfaction and quality of life. J Evid Based Dent Pract 2012; 12 (3Suppl): S182-S184.
28. Kuoppala R, Näpänkangas R, Raustia A. Quality of Life of Patients Treated With Implant-Supported Mandibular Overdentures Evaluated With the Oral Health Impact Profile (OHIP-14): a survey of 58 Patients. J Oral Maxillofac Res 2013; 4: e4.
29. Emami E, de Souza RF, Bernier J, Rompre P, Feine JS. Patient perceptions of the mandibular three-implant overdenture: a practice-based study. Clin Oral Implants Res 2014; 19: [Epub ahead of print]
30. Awad M, Al-Shamrany M, Locker D, Allen F, Feine J. Effect of reducing the number of items of the Oral Health Impact Profile on responsiveness, validity and reliability in edentulous populations. *Community Dent Oral Epidemiol* 2008; 36: 12-20.

31. Preciado A, Del Río J, Suárez-García MJ, Montero J, Lynch CD, Castillo-Oyagüe R. Differences in impact of patient and prosthetic characteristics on oral health-related quality of life among implant-retained overdenture wearers. *J Dent* 2012; 40: 857-865.

32. Awad MA, Locker D, Korner-Bitensky N, Feine JS. Measuring the effect of intra-oral implant rehabilitation on health-related quality of life in a randomized controlled clinical trial. *J Dent Res* 2000; 79: 1659-1663.

33. Yan C, Ye L, Zhen J, Ke L, Gang L. Neuroplasticity of edentulous patients with implant-supported full dentures. *Eur J Oral Sci* 2008; 116: 387-393.

34. Vere J, Hall D, Patel R, Wragg P. Prosthodontic maintenance requirements of implant-retained overdentures using the locator attachment system. *Int Journal Prosthodont* 2012; 25: 392-394.

---

**Illustrations, Figures, Photographs**

Four copies of all figures or photographs should be included with the submitted manuscript. Figures submitted electronically should be in JPEG or TIFF format with a 300 dpi minimum resolution and in grayscale or CMYK (not RGB). Printed submissions should be on high-contrast glossy paper, and must be unmounted and untrimmed, with a preferred size between 4 x 5 inches and 5 x 7 inches (10 x 13 cm and 13 x 18 cm). The figure number, name of first author and an arrow indicating “top” should be typed on a gummed label and affixed to the back of each illustration. If arrows are used these should appear in a different color to the background color. Titles and detailed explanations belong in the legends, which should be submitted on a separate sheet, and not on the illustrations themselves. Written informed consent for publication must accompany any photograph in which the subject can be identified. Written copyright permission, from the publishers, must accompany any illustration that has been previously published. Photographs will be accepted at the discretion of the Editorial Board.