

## 原著

# Improvement of occlusal balance and quality of life in patients by restoration with dental implant

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**Abstract** : Restorations with dental implant have been widely used in missing teeth. However, it has little showed the usability, occlusal efficiency and the patients' satisfaction (Quality of life) objectively. Occlusal contact area, the bite force and oral health-related quality of life (OHRQoL) using the General Oral Health Assessment Index (GOHAI) questionnaire were measured for partially edentulous patients who received dental implant therapy. The occlusal contact area and the bite force of post-prostheses were significantly higher than that of pre-prostheses at the implant-side ( $p < 0.05$ ). The contact area and bite force ratio showed no significantly differences between implant-side and non-implant-side after prostheses, indicating that the balance of occlusal distribution was improved. Occlusal contact area in multiple teeth missing cases was significantly increased in post-prostheses at implant-side ( $p < 0.05$ ), but no statistically significant differences in single tooth missing cases. GOHAI scores was significantly increased after prostheses ( $p < 0.01$ ) in multiple teeth missing cases, whereas no significantly differences between before and after prostheses in single tooth missing cases. Taken together, implant-retained prostheses improved the occlusal function and balance, and it might be useful for restoration of masticatory function and improvement of OHRQoL, especially in multiple teeth missing cases.

**Key words** : dental implant, occlusal balance, quality of life (QOL)

## Introduction

Recently, it has gone of super-aged society, improvement of quality of life (QOL) has become essential. Prosthetic treatment for missing teeth is important from QOL point of view. It is related to masticatory efficiency, speaking abilities, sensuousness, nutrition intake, and psychological satisfaction obtained by eating. Prosthetic patterns have reported to be highest significance to mastication and appearance of their prosthesis<sup>1)</sup>. Most notably, fixed dental

prostheses supported by dental implants are preferred treatment for replacing the missing teeth due to their high predictability, success rate and restoration of the esthetics and function of the tooth<sup>2,3)</sup>. The implants have been used increasingly in prosthodontics.

Occlusion plays an important role in the functional and biological aspects of the implant prosthesis. A stable, well-maintained occlusion can reduce mechanical and biological complications and it leads to the longevity of the prosthesis and the remaining teeth<sup>4)</sup>. The loss of

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occlusal support due to missing posterior teeth increases the remaining region's loading and is difficult to achieve patient satisfaction with functional reconstruction by using the traditional method<sup>5)</sup>. On the other hand, dental implant treatment enables the use of fixed prosthesis that provide a satisfactory result for patients. The masticatory ability is dependent on the number of teeth present<sup>1)</sup>. It has reported that the evaluation of the occlusal contact area, occlusal force, and masticatory efficiency can be useful for assessing masticatory function<sup>6)</sup>. In addition, the maximum bite force that are related to the masticatory performance and efficiency are positively correlated with the occlusal contacts and the occlusal area of natural teeth, and the number of teeth<sup>7)</sup>.

Teeth loss has a negative influence on the Oral Health-Related Quality of Life (OHRQoL)<sup>8)</sup>. OHRQoL is an integral part of general health that includes a subjective evaluation of the individual's oral health, functional well-being, emotional well-being, and so on<sup>9)</sup>. To assess OHRQoL, several tools has been reported such as the Oral Health Impact Profile (OHIP) and the Geriatric Oral Health Assessment Index (GOHAI). The GOHAI that was originally introduced in 1990 is one of the most major instrument to measure OHRQoL and translated into different language including Japanese<sup>10,11)</sup>. Previous reports indicated that implant therapy seems to have a positive effect on OHRQoL<sup>12)</sup>.

There were reports that overdentures with dental implant could improve bite force, and patient's satisfaction<sup>13)</sup>. However, there were only few studies about the effect of implant-retained fix prostheses on occlusal function and OHRQoL. The aim of the present study was to evaluate alteration and effectiveness of the occlusal contact area, bite force, improvement of QOL and the expediency with the implant treatment in the number of them, single or multiple teeth missing cases.

## Materials and methods

### *Patients*

The subjects were partially edentulous patients who received dental implant therapy. Patients with unilateral missing teeth were included in this study. The following patients were excluded: patients with dental implant overdentures, patients who received immediate loading implants. This study was approved by the Ethics Committee of Osaka Dental University (111046). All participants received verbal and written informed consents prior to participating in the study.

### *Clinical procedure*

All implants (Straumann, Nobel Biocare, Astra Tech Dental, Kyocera, Zimmer Biomet Dental, or Ankylos implants) were installed according to the manual and standard procedures using a two-stage procedure. After a healing period of about 3 to 6 months, the implants were uncovered and healing abutments were connected. The implant-supported fixed prostheses were placed for their edentulous spaces.

### *Occlusal contact area and occlusal bite force measurements*

Occlusal contact area and occlusal bite force were measured with a pressure-sensitive system with a pressure-sensitive foil (Dental Prescale II; Fuji Film, Tokyo, Japan). After recording, the foils were scanned by scanner (EPSON GT-X830; Epson, Tokyo, Japan) and analyzed using biteforce analyzer system (Biteforce analyzer software; Fuji Film) and visualized on the display screen. The measurements were performed three times for each patient and the average of three measurements was used. Occlusal contact area and occlusal bite force were calculated at pre- and post- prostheses, respectively. Occlusal contact area ratio was the percentage of implant-side or non-implant-side occlusal contact area in total occlusal contact area. Occlusal bite

force ratio was also calculated in the same manner.

### Oral health-related quality of life

OHRQoL was evaluated using Japanese version of the GOHAI questionnaire. A total of 12 OHRQoL factors were rated on 5-point scales; 1 = always, 2 = often, 3 = sometimes, 4 = seldom, 5 = never. A higher GOHAI total score (range: 12-60) indicates higher OHRQoL. Japanese version of GOHAI was used after submitting an application to iHope International (<https://www.sf-36.jp/index.html>) and receiving approval for its use.

### Statistical analysis

The statistical analyses were performed using the SigmaPlot software 12.3. Differences of occlusal contact area and bite force between pre-prostheses and post- prostheses measurements were analyzed by paired t-test. Differences of occlusal contact area ratio and bite force ratio between implant-side and non-implant-side measurements were analyzed by paired t-test. The Wilcoxon signed rank test was used to compare GOHAI score between pre-prostheses and post- prostheses. The Kruskal-Wallis test was used to compare GOHAI score of pre-prostheses and post- prostheses by number of missing teeth. A  $p$  value less than 0.05 was considered to be statistically significant.

## Results

In total, 15 patients (5 male and 10 female) were included in this study. The average patients age was 64.4 years (range: 31-80 years). The characteristics of the patients were shown in **Table 1**. 4 patients received single implant, 8 patients received two implants, and 3 patients received three implants. 6 cases were maxilla and 9 cases were mandible.

The representative visualized images of occlusal measurement were shown in **Figure 1a-**

**b** (patient No. 7 and 9). The images showed that occlusal contact of edentulous spaces was recovered after prostheses placement. The occlusal load center that indicated the center of distributor occlusal load balance was biased to non-implant-side before prostheses placement. After prostheses placement, the occlusal load center shifted to the center of dental arch.

In order to assess the influence of implant-retained prostheses on the occlusal distribution, occlusal contact area and occlusal bite force were analyzed. The comparison analyses showed that the occlusal contact area and occlusal bite force of post-prostheses placement were significantly higher than that of pre-prostheses placement at the implant-side ( $p < 0.05$ ) (**Figure 2a-b**). At the non-implant-side, the occlusal contact area and occlusal bite force were significantly decreased after prostheses placement compared to before prostheses placement ( $p < 0.05$ ). The total occlusal contact area showed no statistically significant differences between pre-prostheses and post-prostheses placement. The total occlusal bite force was not also significantly different between pre-prostheses

**Table 1** Overview of the patients

Patient (No.)	Gender	Age	Region	Number of implants
1	F	70	┐6	1
2	M	48	┐6	1
3	M	58	┐7	1
4	F	31	6┘	1
5	F	70	6, 5┐	2
6	M	72	7, 6┐	2
7	F	75	└5, 6	2
8	F	63	7, 6┘	2
9	M	80	6, 5, 4┘	2
10	F	74	7, 6, 5┐	2
11	F	71	6, 5, 4┐	2
12	F	67	6, 5, 4┘	2
13	M	59	┐5, 6, 7	3
14	F	55	┐5, 6, 7	3
15	F	73	7, 6, 5┘	3

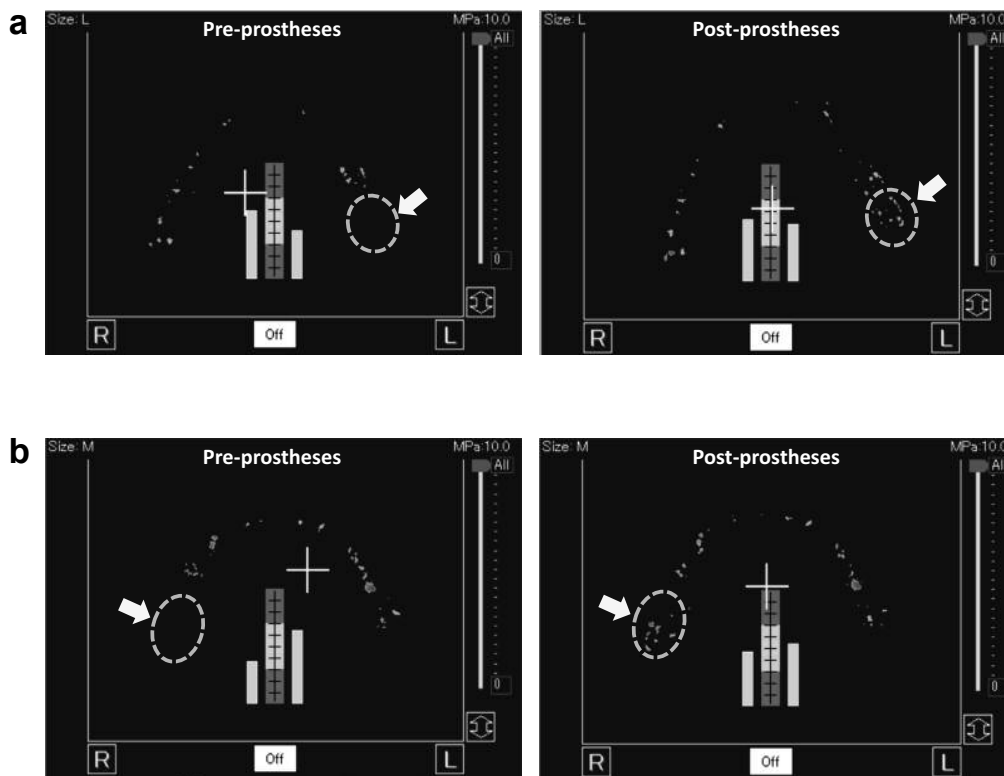
and post-prostheses.

The balance of occlusal distribution was assessed by occlusal contact area ratio and occlusal bite force ratio. Before prostheses placement, occlusal contact area ratio and occlusal bite force ratio were significantly higher in non-implant-side compared to implant-side that had edentulous spaces. Occlusal contact area ratio and occlusal bite force ratio showed no significantly differences between implant-side and non-implant-side after prostheses placement, indicating that the balance of occlusal distribution was improved (Figure 3a-b).

To evaluate the changes in the occlusal distribution depends on the number of the missing teeth, occlusal contact area was compared. In multiple teeth missing cases, occlusal contact area was significantly increased in post-

prostheses compared to pre-prostheses at implant-side ( $p < 0.05$ ) and it was significantly decreased in post-prostheses at non-implant-side (Figure 4a-b). On the other hand, there was no statistically significant differences between pre-prostheses and post-prostheses placement in single tooth missing cases.

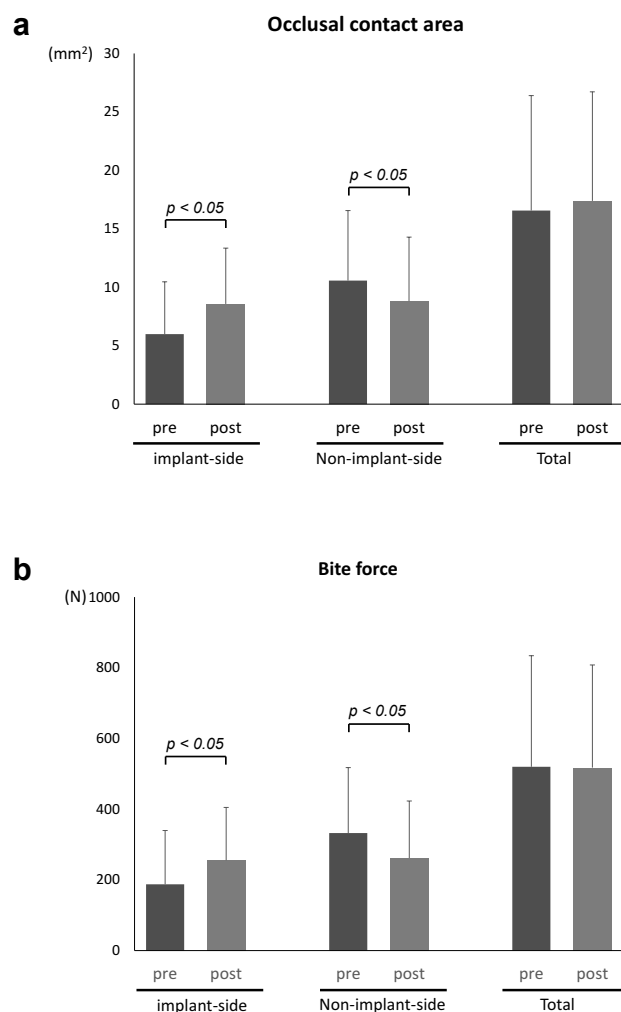
The total GOHAI scores was significantly increased after prostheses placement compared to before prostheses placement ( $p < 0.01$ ) (Figure 5a). In multiple teeth missing cases, GOHAI scores was significantly increased after prostheses placement ( $p < 0.01$ ), whereas there was no significantly differences between before and after prostheses placement in single tooth missing case (Figure 5b). In addition, GOHAI scores of single tooth missing cases and multiple teeth missing cases before prostheses placement showed significantly differences ( $p < 0.05$ ).



**Figure 1** Representative images of occlusal measurements (patient No.7 (a) and 9 (b)).

The density of color indicates the degree of applied pressure.

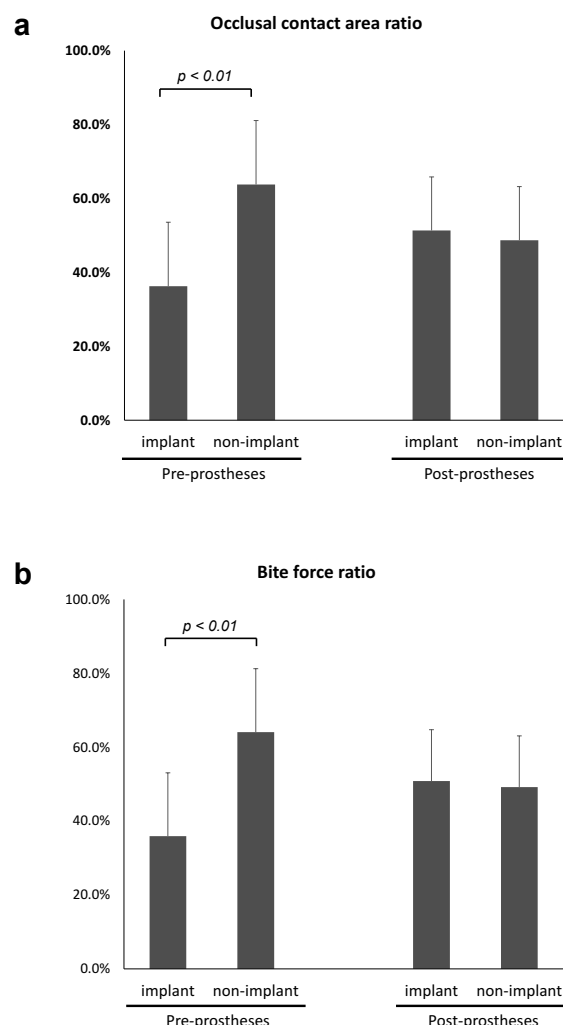
Left; pre-prostheses, Right; post-prostheses, +; occlusal load center.



**Figure 2** Occlusal contact area (a) and occlusal bite force (b) of pre-prostheses and post-prostheses. Occlusal contact area and occlusal bite force were calculated in implant-side, non-implant-side, and total, respectively. Bar: standard deviation.  $p < 0.05$

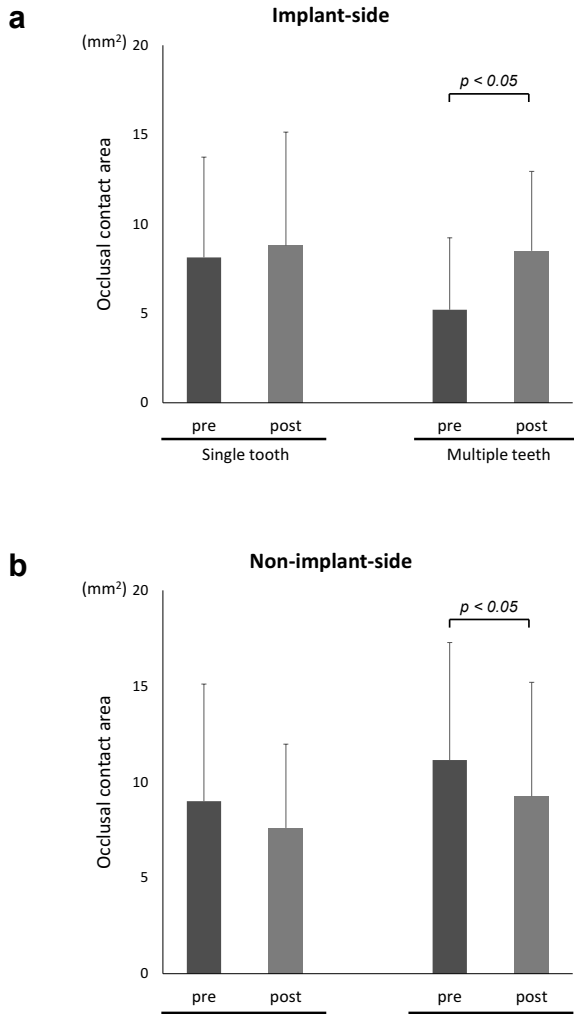
## Discussion

The masticatory performance is important factor in case of living energetic life with promising QOL in the present super-aged era. Its function of edentulous patients is also significantly lost, compared with that of natural dentitions<sup>14)</sup>. Generally, conventional removable dentures have been used for restoration of missing teeth. However, it is difficult to recover fully masticatory efficiency<sup>15)</sup>. Evaluation of masticatory function using pressure detecting



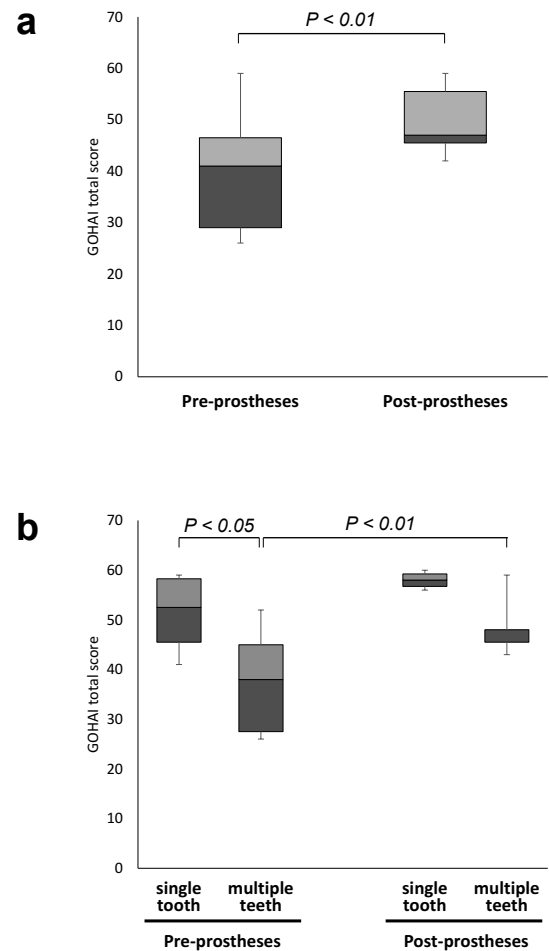
**Figure 3** Occlusal contact ratio (a) and occlusal bite force ratio (b) of implant-side and non-implant-side. Occlusal contact area ratio and occlusal bite force ratio were calculated in pre-prostheses and post-prostheses, respectively. Bar: standard deviation.  $p < 0.01$

sheet indicated that the biting forces were 35% and 11% for the removable partial denture and complete denture wearers, respectively, compared with natural dentition<sup>16)</sup>. On the other hand, fixed prostheses by dental implants are a preferred treatment for replacing missing teeth due to the high predictability and success rate<sup>2,3)</sup>. There may be presumed that implant-retained and/or -supported prostheses would be superior to conventional complete dentures which would represent the standard treatment for edentulous patients in a number of ways<sup>15)</sup>. In



**Figure 4** Occlusal contact area of pre-prosthesis and post-prosthesis at implant-side (a) and at non-implant-side (b) in single tooth and multiple teeth. Bar: standard deviation.  $p < 0.05$

this study, we focused on occlusal condition such as occlusal contact and bite force that are associated with masticatory function and QOL, and assessed implant-retained prostheses. To make quantitative analyses of occlusal contact area and occlusal force in the intercuspal position, Dental Prescale II system was used in this time. The system has been widely performed for healthy dentate subjects, orthodontic patients, removable denture patients and so on<sup>17)</sup>. Our results showed that the occlusal contact area and bite force were significantly



**Figure 5** A box-and-whisker plots comparing changes in GOHAI scores pre-prosthesis and post-prosthesis placement (a). A box-and-whisker plots of GOHAI scores based on the number of missing teeth (b).

increased in implant-side by using dental implants-retained prostheses (Figure 2). The assessment of occlusal distribution demonstrated that there were significant differences in the ratio of occlusal contact area and bite force between implant-side and non-implant-side before prosthesis indicating that occlusal balance was leaning more towards non-implant-side. However, no significant differences were observed between these sides after prostheses (Figure 3). The results of occlusal load center also indicated that the occlusal balance changed to be toward

the center of dental arch after prostheses placement (**Figure 1**). Therefore, dental implant prostheses may have a favorable effect on the distribution of implant-side occlusal force and occlusal contact area, and this approach would be able to restore the proper balance of occlusal force and area on the non-implant-side. On the other hand, no significant differences were observed in the total contact area and bite force post-prostheses compared to pre-prostheses. Subsequently, we also investigated the effect of the dental implants' numbers. The occlusal contact area at implant and non-implant-side showed no statistically significant differences between pre- and post-prosthesis in single implant cases, but it in multiple implants cases showed statistically significant differences (**Figure 4**). These results suggest that the use of implant prostheses in multiple implants cases might be effective for restoring the occlusal contact area and decreasing the occlusal load on the non-implant-side of residual natural teeth. It was reported that implant prostheses provide significant increases in the maximum occlusal force, contact area, and masticatory ability in patients treated with one to four implant-supported single crowns<sup>18)</sup>. Other study also reported that the occlusal force and occlusal area on the implant-side significantly increased in 1<sup>st</sup> and 2<sup>nd</sup> molars missing cases but not in only 1<sup>st</sup> molar missing cases<sup>19)</sup>. Therefore, in multiple teeth cases, the use of an implant prosthesis might have a favorable effect on occlusal contact area, not single tooth case. However, associations between implant prostheses and development of a higher occlusal force and area, and functional improvement remain unknown<sup>19)</sup>.

Even overdenture cases treated with dental implants to support prosthesis, the masticatory function, satisfaction and QOL was higher than cases treated with conventional dentures<sup>20)</sup>. In multiple teeth missing cases, GOHAI scores of post-prostheses (median: 48; range: 43-59) were higher than that of pre-prostheses (median: 38;

range: 26-52) indicating improvement of OHRQoL. On the other hand, in single tooth missing cases, GOHAI scores of pre-prostheses (median: 52.5; range: 41-59) and post-prostheses (median: 58; range: 56-60) did not show significant differences (**Figure 5**). The previous study reported that GOHAI scores showed strong relationship with number of remaining teeth<sup>11)</sup>. Our group also indicated that GOHAI scores decreased as the number of occlusal supports decreased<sup>21)</sup>. Since GOHAI scores of pre-prostheses in single tooth missing cases were comparable to that of Japanese national standard, no statistically significant improvement was shown. Therefore, QOL by this fixed dental implant restorations would be related to the number of missing teeth. The effect of implant treatment on OHRQoL might be higher in multiple implants cases.

In this study, dental prescale system was used to evaluate the occlusal distribution. This system is useful to measure occlusal contact area and occlusal bite force in intercuspal position. However, in general, people have their habitual chewing side and masticate at more useful side to crunch. The habitual chewing side might be related to the path of masticatory movement, masticatory rhythm, occlusion, and the dominant hand<sup>22)</sup>. Since it might be difficult to record habitual masticatory movement in this system, further development to assessment occlusal performance is required.

## Conclusion

Implant-retained prostheses significantly increased the occlusal contact area and bite force in implant-side and restored the proper balance of occlusal force and area in dental arch. In addition, occlusal area was significantly increased in multiple implants cases but not in single implant cases. Improvement of OHRQoL was also observed in multiple implants cases. Taken together, implant-retained prostheses



might be useful for restoration of masticatory function, especially in multiple teeth missing cases.

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## Competing interests

The authors declare that they have no conflict of interests.

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