

原著

The significant improvement of tongue pressure after implant-supported prostheses

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Abstract : Implant-supported prostheses have been widely accepted for edentulous or partially edentulous patients. However, few studies have examined the relationship between masticatory performance and implant-supported prostheses treatment. The aim of the study was to assess changes in biting abilities, maximum tongue pressure, and oral health-related quality of life in subjects with implant-supported restoration. Twenty partially edentulous patients who received dental implant therapy were included in this study. Biting abilities including occlusal contact area, bite force, maximum occlusal pressure, and average occlusal pressure, maximum tongue pressure, and oral health-related quality of life (OHRQoL) were evaluated. The assessments were performed at the baseline (pre-implant prostheses), post-implant prostheses, 1, 3, 6, and 12 months after implant prostheses placement. Biting abilities showed no statistically significant differences throughout the entire period. Maximum tongue pressure measurement was significantly increased at 12 months compared to before implant-supported prostheses treatment. OHRQoL was significantly increased at 1 month, 3 months, 6 months, and 12 months after prostheses placement compared to before prostheses placement. Placement of implant-supported prostheses for partially edentulous patients significantly improved the maximum tongue pressure and OHRQoL.

Key words :tongue pressure; dental implants; quality of life

Introduction

Implant-supported fixed dental prostheses is a promising treatment for the replacement of missing teeth. Treatment with fixed prostheses achieved better results regarding quality of life, oral satisfaction, and masticatory function than treatment with removable prostheses.¹⁾ Improvements in masticatory function are often a primary reason for the selection of implant-supported treatment. In addition, the high predictability, success rate and restoration of

esthetics are reasons why implant-supported prostheses have been increasingly accepted as an alternative to conventional dentures. However, the time-dependent effects that dental implant treatment have on the oral function, such as bite abilities and tongue function, remain unknown.

Tongue movement, occlusal contact area, and occlusal force are the factors relating to masticatory performance. Tongue pressure is a non-invasive and easy way to measure tongue muscle strength.^{2,3)} It is associated with masticatory performance in oral function^{4,5)} and

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used to diagnose oral hypofunction. Decreases in tongue pressure are related to the dysphagia seen in patients with neurodegenerative diseases.⁶⁻⁹⁾ Tongue pressure also decreases with age.¹⁰⁾ However, no reports have assessed the relationship between tongue pressure and implant treatment.

Quality of life has been widely recognized as a useful parameter when assessing physical and mental health care, including oral health.¹¹⁾ The patient-perceived impact of treatment is now considered a highly important tool to evaluate treatment success.¹²⁾ The concept of oral-health-related quality of life (OHRQoL) is widely used to consistently measure patient-perceived impact across different oral health conditions. Tooth loss affects quality of life due to the loss of oral function and the retention of teeth is associated with better OHRQoL.¹¹⁾ Since OHRQoL is used to assess the effect of dental interventions, OHRQoL measures are a valuable tool to evaluate implant-supported prostheses treatment.

The purpose of this study was to investigate the influence of implant-supported prostheses on bite abilities, tongue pressure, and OHRQoL during the follow-up period in a time-dependent manner.

Materials and methods

Participants

Twenty partially edentulous patients (mean age 55.1 years, range 22-84) who received dental implant therapy were included in this study. All patients had unilateral missing teeth. The following patients were excluded: patients with dental implant overdentures, patients who received immediate loading implants. All participants received verbal and written informed consents prior to participating in the study. This study protocol was approved by the Ethics Committee of Osaka Dental University (111046).

Experimental protocol

All implants were installed with a two-stage procedure according to the standard procedures. After a healing period, the implants were uncovered and healing abutments were connected. The implant-supported fixed prostheses were placed for their edentulous spaces. Biting abilities (occlusal contact area, bite force, maximum occlusal pressure, and average occlusal pressure), maximum tongue pressure, and oral-health-related quality of life were assessed before implant treatment and during follow-up periods. The assessments were performed at the baseline (pre-implant prostheses), post-implant prostheses, 1, 3, 6, and 12 months after implant prostheses placement.

Biting abilities measurements

Occlusal contact area, bite force, maximum occlusal pressure, and average occlusal pressure were recorded as previously described.¹³⁾ In brief, a pressure-sensitive system with a pressure-sensitive foil (Dental Prescale II; Fuji Film, Tokyo, Japan) was used according to the manufactured instruction. The patients were seated with their heads in a vertical position and instructed to bite the Dental Prescale sheet with the maximal bite force. After measuring, the foils were scanned by scanner (EPSON GT-X830; Epson, Tokyo, Japan), 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.

Tongue pressure measurement

Maximum tongue pressure was measured using a tongue pressure measuring device, JMS-TPM (JMS Co., Ltd., Hiroshima, Japan). The balloon was put in the participant's mouths, with lips closed. The patients were asked to raise their tongue and push the balloon against their palate

using maximum efforts for seven seconds. The measurements were performed three times for each patient and the average of three measurements was used as the maximum tongue pressure.

Oral health-related quality of life

OHRQoL was evaluated using Japanese version of the GOHAI questionnaire as previously described.¹³⁾ In brief, 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. Statistical differences in biting abilities and maximum tongue pressure during follow-up periods were analyzed by Tukey’s test following one way repeated measures analysis of variance. Friedman repeated measures analysis of variance on ranks was used to compare GOHAI score among measurements during follow-up periods. The presence or absence of a statistically significant correlation between the maximum tongue pressure and age was analyzed by Pearson’s correlation coefficient. A *p* value of less than 0.05 was considered to be statistically significant.

Results

A total of 20 patients (7 male and 13 female) with a mean age of 55.1 years were included in this study. The patients’ characteristics are shown in **Table 1**. Eleven cases were intermediate missing cases and nine cases were free-end missing cases. Upper cases were 11 and lower cases were 9. The baseline (pre-prostheses) data are shown in **Table 2**. A comparison of the baseline data on patients’ age, occlusal contact area, bite force, maximum occlusal pressure, average occlusal pressure, and maximum tongue pressure revealed that no significant differences were found between free-

Table 1 Patients characteristics

Characteristics		
Age		55.1±15.3
Gender	Male	7
	Female	13
Number of Missing teeth	1	12
	2	3
	3	5
Missing pattern	Intermediate	11
	Free-end	9

Table 2 Baseline data of the patients

	Free-end	Intermediate
Age	58.3±11.5	52.4±17.9
Occlusal contact area (mm ²)	25.9±15.8	26.2±9.7
Bite force (N)	765.4±441.9	797.0±283.5
Maximum occlusal pressure (Mpa)	100.0±20.4	107.7±13.4
Average occlusal pressure (Mpa)	30.1±5.1	31.0±3.7
Maximum tongue pressure (kPa)	33.4±7.0	39.9±8.8

end missing cases and intermediate missing cases.

In order to determine the effect of implant-supported prostheses on bite abilities, occlusal contact area, bite force, maximum occlusal pressure and, average occlusal pressure were measured. The results showed no statistically significant differences throughout the entire period in all cases, free-end missing cases, and intermediate missing cases, respectively (Figure 1A-D).

A comparison between the maximum tongue pressure and the patients' age revealed no correlation (Figure 2A). Maximum tongue

pressure measurements showed that this was significantly increased at 12 months compared to before implant-supported prostheses treatment ($p<0.05$) (Figure 2B). In the free-end missing cases, maximum tongue pressure was significantly increased at 3 months ($p<0.05$), 6 months ($p<0.05$), and 12 months ($p<0.001$) compared to before prostheses (Figure 3A). On the other hand, no significant differences were found in the intermediate missing cases throughout the entire period (Figure 3B).

The total GOHAI scores was significantly increased at 1 month, 3 months, 6 months, and 12 months after prostheses placement compared to

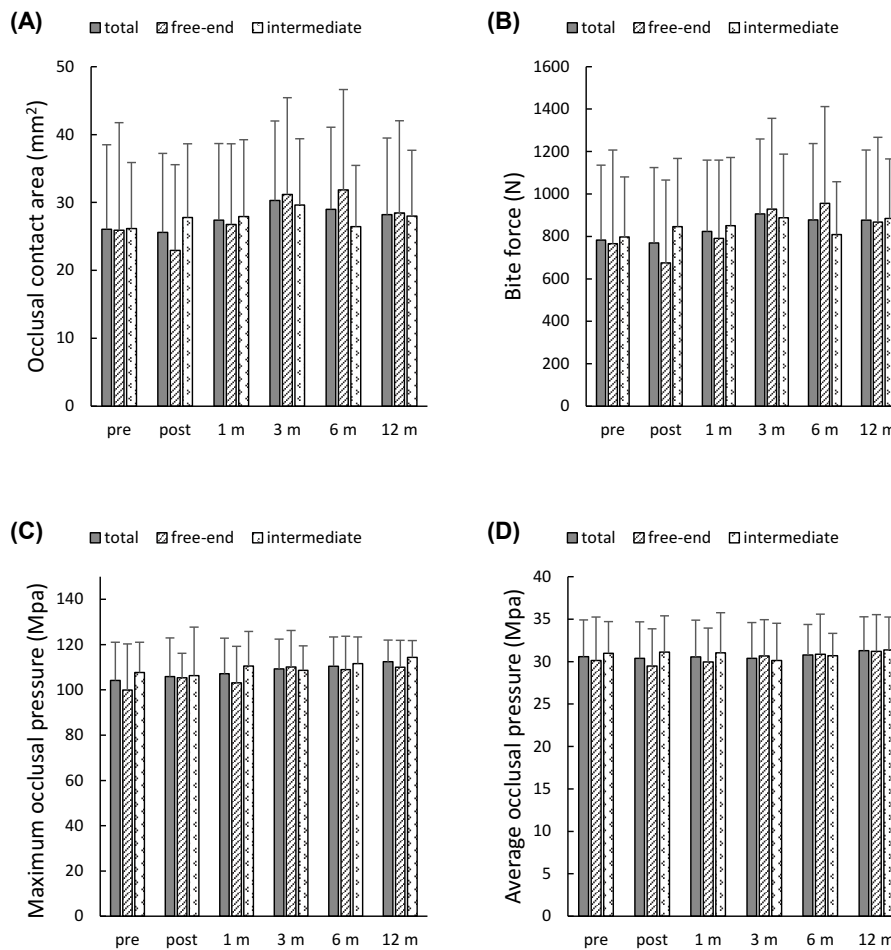


Figure 1 Biting abilities measurements before and after implant-supported prostheses. The mean values and the standard deviations of all cases, free-end missing cases, and intermediate missing cases are shown. (A) Occlusal contact area. (B) Bite force. (C) Maximum occlusal pressure. (D) Average occlusal pressure. Bar: standard deviation.

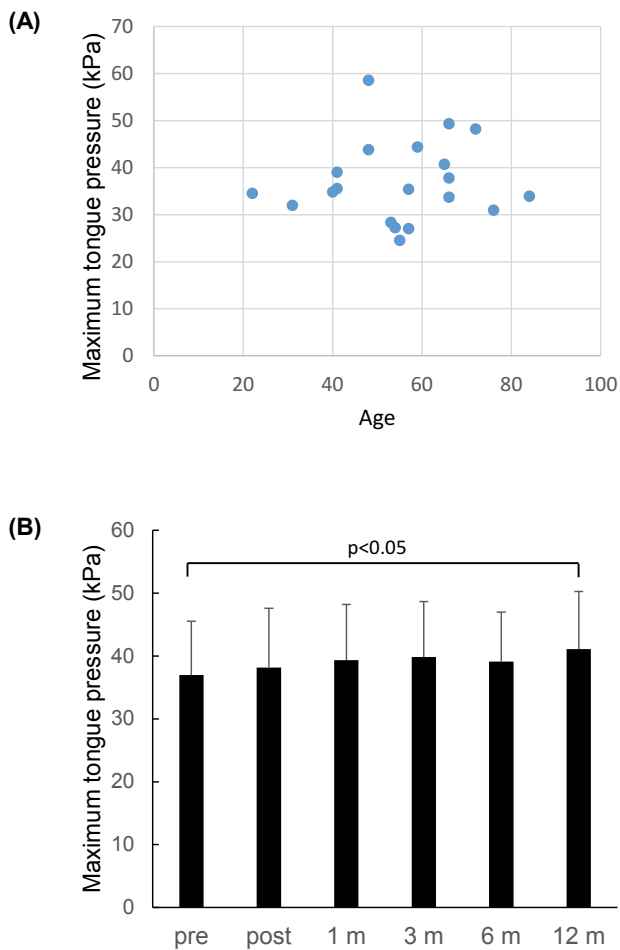


Figure 2 Maximum tongue pressure measurement. (A) Correlation between the maximum tongue pressure at baseline and age. (B) Maximum tongue pressure measurement before implant-supported prostheses and follow-up periods. Bar: standard deviation.

before prostheses placement, respectively ($p < 0.05$) (Figure 4A). In both free-end and intermediate missing cases, the total GOHAI scores was also significantly increased after implant-supported prostheses compared to before prostheses placement (Figure 4B, C).

Discussion

The tongue plays an important role in mastication and swallowing. It carries ingested food to the molars, forms a bolus by mixing the

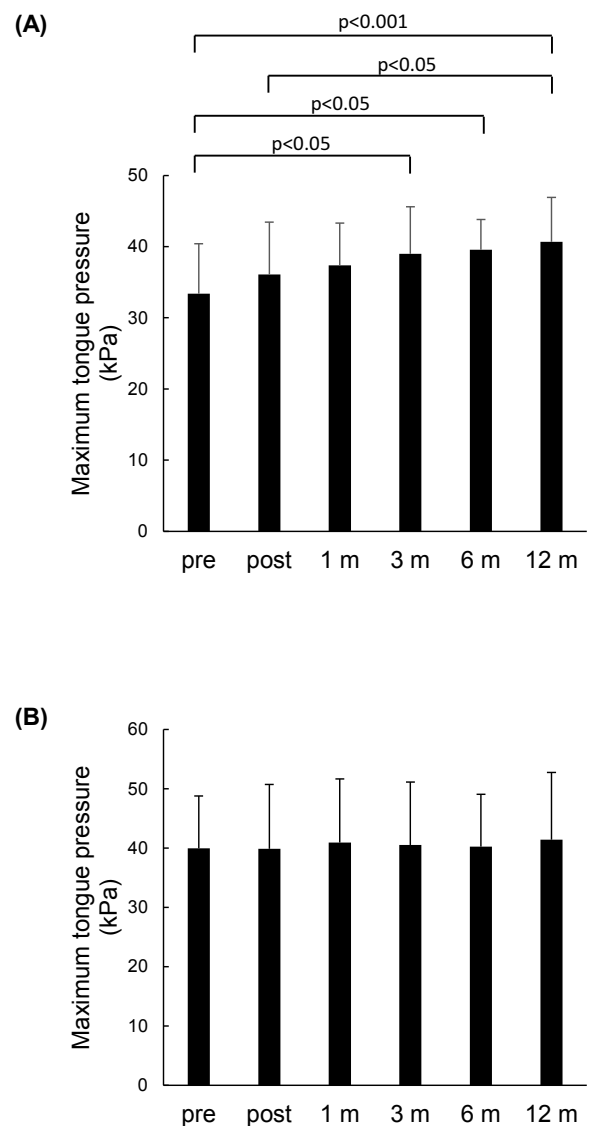


Figure 3 Comparison of maximum tongue pressure based on missing pattern. (A) Free-end missing cases. (B) Intermediate missing cases. Bar: standard deviation.

food with saliva, and propels bolus from oral cavity into the pharynx.¹⁴⁾ Tongue pressure is the force that is pressed voluntarily against the palate and used to assess tongue function.¹⁴⁾ The previous studies indicated that tongue pressure is associated with several factors, such as gender, age, history of stroke, lean body mass, grip strength, and HbA1c.¹⁵⁻¹⁷⁾ In addition, it has been reported that tooth loss is significantly

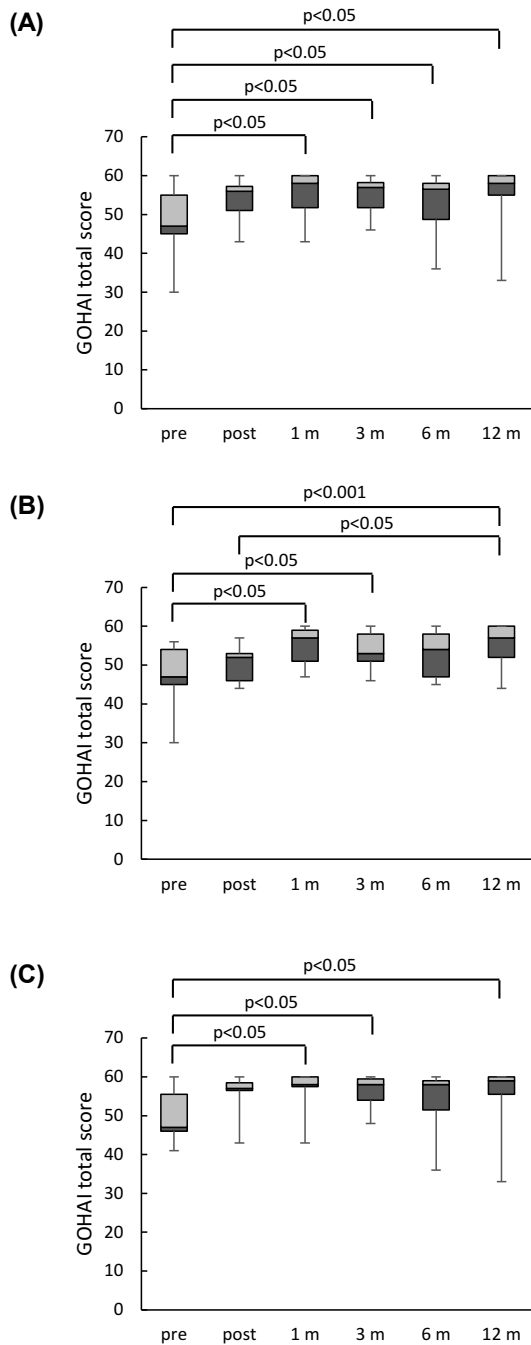


Figure 4 A box-and-whisker plots comparing changes in GOHAI scores during follow-up periods.

- (A) All patients.
- (B) Free-end missing cases.
- (C) Intermediate missing cases.

associated with lower tongue pressure.¹⁵⁾ However, few studies examined the relationship between tongue pressure and implant-supported prostheses treatment. In this study, it was

revealed that implant-supported prostheses had a positive effect on maximum tongue pressure.

The most commonly used device for measuring tongue pressure is the Iowa Oral Performance Instrument (IOPI) (IOPI Medical LLC, Washington, USA), which was patented in 1992.^{3,18)} To measure maximum tongue pressure, a JMS tongue-pressure-measuring device, that was developed in Japan,¹⁹⁾ was used in the present study. This device consists of a probe, connecting the tube and main body. A recent study revealed that maximum tongue measurements using the IOPI and JMS were significantly different but correlated.³⁾ The Japanese standard maximum tongue pressure, measured by the JMS tongue-pressure-measuring device, was 41.7 ± 9.7 kPa in the twenties, 41.9 ± 9.9 kPa in the thirties, 40.4 ± 9.8 kPa in the forties, 40.7 ± 9.8 kPa in the fifties.¹⁰⁾ In this study, the maximum tongue pressure before prostheses placement was 35.7 ± 9.2 kPa in 20-59-year-old subjects. The value was lower than that of the healthy Japanese subjects, indicating that fewer than three missing teeth might influence the tongue pressure. After prostheses treatment, the maximum tongue pressure was increased to the standard level (42.1 ± 10.5 kPa). In free-end missing cases, the average maximum tongue pressure before prostheses was 33.4 ± 7.0 kPa, and this was significantly increased to 39.0 ± 6.6 kPa, 39.5 ± 4.3 kPa, and 40.7 ± 6.2 kPa at 3, 6, and 12 months, respectively. These results suggested that implant-supported prostheses treatment might restore the reduction in tongue pressure, especially in free-end missing cases. On the other hand, there was no significantly differences between before and after implant-supported prostheses treatment in intermediate missing cases. The reason was that the maximum tongue pressure in unilateral intermediate missing cases was comparable to that of the standard level even at pre-treatment. Since tongue played an important role in swallowing,¹⁴⁾

unilateral intermediate tooth loss may have little influence on swallowing function.

The previous study indicated that the masticatory performance of crushing abilities was significantly correlated with maximum tongue pressure.²⁰⁾ The other study demonstrated that there was a significant correlation between mixing ability and maximum tongue pressure in elderly people with no occlusal support.²¹⁾ Since the maximum tongue pressure was significantly improved by implant-supported prostheses placement, implant treatment might exert positive effects on masticatory performance. Some studies indicated that implant-supported overdenture presented significant improvements in masticatory performance.²²⁻²⁴⁾ In partially edentulous patients, the use of removable partial dentures, fixed prosthodontics, or implant-supported removable partial dentures improved masticatory function by 10%-30%.^{1,25,26)} In patients with unilateral posterior missing teeth, significant reductions of 29.3% in the median particle size during freestyle mastication were obtained from unilateral mastication on the treated side after 3-months treatment.²⁶⁾ These reports also supported our results that the increase in the maximum tongue pressure by implant-supported prostheses may lead to improvements in the masticatory performance.

In this study, bite abilities, including occlusal contact area, bite force, maximum occlusal pressure, and average occlusal pressure, were not significantly increased after implant-supported prosthesis placement. The results were comparable to our previous report that the total occlusal contact area and the total occlusal bite force showed no statistically significant differences between pre-prostheses and post-prostheses placement.¹³⁾ In contrast, the other study reported that implant prostheses provide significant increases in the total occlusal contact area and the total maximum occlusal force in patients treated with from one to four

implant-supported single crowns.²⁷⁾ This is possibly due to the differences in measurement timepoints and the number of missing teeth between the two studies. They compared these bite abilities before crown cementation and 1 month after crown cementation, while our study evaluated bite abilities throughout the long-term follow-up period (1, 3, 6, and 12 months). Since fewer than three missing teeth cases were including in this study and 12 out of 20 cases were single missing tooth cases, bite abilities might show no significant differences after prostheses. Implant-supported prosthesis in more missing teeth cases may influence bite abilities.

OHRQoL are used to evaluate the oral conditions regarding quality of life and assess the effect of dental interventions.²⁸⁾ Previous systematic reviews suggest that rehabilitation with dental implants in edentulous and partially edentulous patients could improve OHRQoL.²⁹⁾ Our group also indicated that GOHAI scores decreased as the number of occlusal supports decreased and GOHAI scores significantly increased after prostheses placement in multiple teeth missing cases.^{11,30)} In this study, GOHAI scores significantly improved 1 month after prostheses placement and were maintained for up to 12 months. The results indicated that implant-supported prostheses might have long-term positive effects on OHRQoL.

Conclusion

The placement of implant-supported prostheses significantly improved the maximum tongue pressure, especially in free-end missing cases. Implant-supported prostheses also had long-term positive effects on OHRQoL. The findings from the present study indicated that implant treatment might be useful for the restoration of masticatory performance.

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Competing interests

The authors declare that they have no conflict of interests.

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