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Original Article

# Effect of treatment with implant-supported fixed partial dentures on oral health-related quality of life in patients with unilateral shortened dental arch

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## KEYWORDS

Implant-supported fixed partial dentures;  
Oral health-related quality of life;  
Partially edentulous;  
Patient-reported outcome measures;  
Shortened dental arches

**Abstract** *Background/purpose:* Implant-supported fixed partial dentures (IFPDs) are a treatment option for partially edentulous dentition with missing posterior-most molars despite the concept of a shortened dental arch (SDA). This study aimed to evaluate the effect of IFPD treatment on oral health-related quality of life (OHRQoL) in patients with unilateral SDA missing two adjacent molars and to compare the effects of single- and two-unit IFPDs.

*Materials and methods:* Forty patients with unilateral SDA missing two adjacent molars (Kennedy Class II) participated in this study; 11 patients received one implant placement in the first molar and were treated with a single-unit IFPD (single-unit group), and 29 received two implant placements and were treated with a two-unit IFPD (two-unit group). The Oral Health Impact Profile (OHIP) questionnaire for OHRQoL assessment and the gummy jelly test for objective masticatory performance were administered before and after IFPD treatment. The Wilcoxon signed-rank test for all patients and Mann–Whitney *U* test were performed for pre- and post-treatment comparisons and between-group comparisons, respectively.

*Results:* The OHIP summary score and gummy jelly glucose concentration in all patients showed significant improvements after treatment (all  $P < 0.05$ ). No significant differences were observed between the single- and two-unit groups for any of the items. Using the minimal important difference in the OHIP summary score, 63.6 % and 58.6 % of patients in the single- and two-unit groups, respectively, showed improvement by 6 points or more.

*Conclusion:* IFPD treatment for patients with SDA missing two adjacent molars may provide clinically meaningful improvements in OHRQoL.

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## Introduction

Loss of natural teeth can impact an individual's oral health-related quality of life (OHRQoL).<sup>1</sup> Permanent teeth extracted early in life due to dental problems, such as caries, are the first and second molars, and implant-supported fixed partial dentures (IFPDs) are often selected for replacement.<sup>2</sup>

Nevertheless, for patients with the loss of the posterior-most molars (Kennedy Class I and II cases), treatment strategies based on the shortened dental arch (SDA) concept, i.e., the idea of follow-up without aggressive prosthetic intervention, may be a more viable alternative to conventional prosthetic treatment.<sup>3</sup> This SDA concept, proposed by Käyser in 1981, states that adequate oral function can be maintained if at least four occlusal units (one and two occlusal units corresponding to a pair of occluding premolars and molars, respectively) are present.<sup>4</sup> For instance, no difference in OHRQoL was detected when comparing the SDA approach with prosthetic interventions, such as removable partial denture treatment;<sup>5–7</sup> hence, the wait-and-see approach in SDA cases is likely to maintain acceptable OHRQoL in the long term.

Considering the subtypes of SDA, patients who lost only the second molar contact were reported to exhibit significantly better OHRQoL than patients with other patterns of SDA.<sup>8</sup> SDA is widely accepted in clinical practice, as only 3.3 % of patients with missing second molars opted for treatment with IFPDs.<sup>9</sup> In contrast, 58 % of patients with SDA missing the first and second molars received prosthetic intervention.<sup>9</sup> Studies on prosthetic intervention in patients with SDA have focused on removable partial dentures and cantilever bridges,<sup>5,6</sup> and no research has systematically examined the efficacy of IFPD treatment interventions. Conversely, the favorable outcomes of IFPD treatment in the molar region have been noted,<sup>10,11</sup> irrespective of the SDA cases. Consequently, the extent to which OHRQoL improvement is achievable following IFPD treatment in patients with SDA missing two adjacent molars remains unclear. When using IFPDs to treat patients with two missing molars, the restoration of either one tooth up to the first molar or two teeth up to the second molar occurs. However, the differences between the treatment efficacy of these two options remain uncertain.

The primary objective of this study was to evaluate the effect of IFPD treatment on OHRQoL in patients with unilateral SDA missing two adjacent molars. The secondary objective was to compare the treatment effect on OHRQoL between IFPDs extending to one tooth up to the first molar and IFPDs involving two teeth up to the second molar. The null hypotheses were “there is no difference in OHRQoL before and after IFPD treatment for patients with SDA missing two adjacent molars” and “there is no difference in the improvement in OHRQoL between IFPDs up to the first and second molars.”

## Materials and methods

### Study population

We recruited patients, aged  $\geq 20$  years, who visited a university dental hospital (Tokyo, Japan) and a private clinic (Saitama, Japan) between April 2021 and September 2023. Eligible patients had unilateral SDA (Kennedy Class II partially edentulous dentition) with missing adjacent first and second molars in either the maxilla or mandible and were seeking IFPD treatment in that region. Exclusion criteria were the use of removable partial dentures, presence of missing teeth unrestored with fixed prostheses except for the target site, presence of an erupted third molar posterior to the two missing molars (i.e., Kennedy Class III), and difficulty answering self-administered questionnaires.

After examination and explanation of treatment options, the patients selected a treatment plan. Patients opting for a single implant and receiving treatment with a single-unit IFPD were categorized into the single-unit group. Patients choosing two implants placed and treated with a two-unit IFPD were classified into the two-unit group.

We adhered to the Declaration of Helsinki; our study protocol was approved by the Institutional Ethics Committee (22-203-A). Written informed consent was obtained from patients before their participation.

### Sample size calculation

The sample size was calculated using G\*Power version 3.1 (Heinrich-Heine-Universität Düsseldorf, Düsseldorf, Germany). An SDA study by Fueki et al. reported that the Oral Health Impact Profile (OHIP) summary score decreased from 29.9 at baseline to 14.7 and 20.2 at 6 and 12 months after IFPD treatment, respectively,<sup>12</sup> suggesting an effect size of 0.4–0.6. Therefore, a medium effect size ( $d = 0.5$ ) was set based on the benchmark proposed by Cohen.<sup>13</sup> The required sample size was calculated to be 35, ensuring 80 % power and a 5 % significance level in a two-tailed Wilcoxon signed-rank test. Considering the possibility of dropouts, the sample size was set to 40.

### Implant placement and prosthetic procedures

Implant placement was planned for either type 3 (typically 12–16 weeks after tooth extraction) or type 4 (typically more than 6 months).<sup>14</sup> In the single-unit group, one implant was placed in the first molar position. The two-unit group had two implants placed: one in the first molar position and another in the second molar position. Implant manufacturers were selected from Straumann® (Straumann Holding AG, Basel, Switzerland) or Nobel Biocare™

(Nobel Biocare Services AG, Kloten, Switzerland). Implant placement was performed under local anesthesia according to the manufacturer's recommended procedure. Bone graft procedures were performed as required. The implants were loaded after a healing period of approximately 3–6 months. After the impressions were obtained, single-unit, non-cantilever IFPDs were fabricated in the single-unit group, whereas two-unit IFPDs were fabricated in the two-unit group. The IFPDs were fixed to the implant body or abutment using screws or cement, according to the literature.<sup>15,16</sup>

### Data collection

Demographic and intraoral data were recorded after patient enrollment. The OHRQoL and masticatory performance were evaluated before implant placement (pre-treatment) and 1 month after placement of the final IFPDs (post-treatment).

### OHRQoL questionnaire

The OHRQoL was evaluated using the Japanese version of the Oral Health Impact Profile (OHIP-J),<sup>17</sup> which comprises 49 items from the English version of OHIP-49 and five items specific to the Japanese population. Patients respond to the frequency of oral problems experienced in the last month on a 5-point Likert scale, with 0 representing "not at all" and 4 representing "very often." To allow for international comparisons, an OHIP-49 summary score with a range of 0–196 was calculated;<sup>18</sup> a lower OHIP score indicated a better OHRQoL. In addition, four-dimensional scores representing aspects of oral health (*Oral Function*, 10 items; *Orofacial Appearance*, 6 items; *Orofacial Pain*, 7 items; and *Psychosocial Impact*, 18 items) were calculated.<sup>19,20</sup> If any of the OHIP item scores were missing, the median of the patient's non-missing values was imputed; data with five or more missing answers were excluded from the analysis.<sup>19</sup>

### Masticatory performance evaluation

Masticatory performance was evaluated by measuring the glucose concentration in the chewed gummy jelly once. The patients were asked to chew a standardized gummy jelly (Glucolumn; GC Corp., Tokyo, Japan) with 10 mL of water for 20 s and spit it out through a dedicated filter into a cup. The glucose concentration of the filtrate containing glucose eluted from the gummy jelly was measured using a dedicated glucose meter based on the glucose oxidase reaction (Gluco Sensor GS-II; GC Corp.).<sup>21</sup>

### Statistical analyses

Patient characteristics and implant-related parameters were compared between the single- and two-unit groups using the Student's *t*-test or Fisher's exact test. The pre- and post-treatment values of the OHIP summary score, four-dimensional scores, and masticatory performance were compared using the Wilcoxon signed-rank test for all patients and the single- and two-unit groups because the Shapiro-Wilk normality test did not show a normal

distribution. Cohen's *d* with Hedges' correction as the effect size was calculated from the pre- and post-treatment values. Changes in the OHIP summary score, four-dimensional scores, and masticatory performance were compared between the single- and two-unit groups using the Mann–Whitney *U* test. The number of patients with improvement (change of –1 point or more) in the OHIP summary score was calculated based on pre- and post-treatment changes. As a minimal important difference (MID) of 6 or more points on the OHIP summary score was proposed due to prosthetic treatment,<sup>22</sup> the number of patients who showed a significant change was calculated using the MID as the index. Statistical analyses were performed using the JMP Pro 16.0 software package (JMP Statistical Discovery LLC, Cary, NC, USA), with a significance level of 0.05.

## Results

### Patient characteristics and implant-related parameters

A total of 40 patients (11 in the single-unit group and 29 in the two-unit group) participated in this study. The patient characteristics and implant-related parameters for each group are shown in Table 1. No dropouts or loss of implants were observed.

### Pre- and post-treatment comparisons

Pre- and post-treatment comparisons of the OHIP scores and glucose concentrations in all patients and in each group are shown in Table 2. The OHIP summary score, four-dimensional scores, and glucose concentration showed significant improvements following treatment (all  $P < 0.05$ ). The effect size of the OHIP summary score for all patients was 0.604. Dimension scores of *Oral Function* and *Orofacial Appearance* were significantly improved after treatment in both the single- and two-unit groups. The OHIP summary score of the two-unit group showed a significant improvement, whereas that of the single-unit group did not. Glucose concentrations significantly improved in the two-unit group. The effect size of the OHIP summary score was 0.633 in the two-unit group, which was greater than that in the single-unit group (0.481).

### Between-group comparisons

Table 3 shows the results of between-group comparisons of pre- and post-treatment changes in OHIP scores and glucose concentrations. No significant differences between the two groups were observed for any of the items.

The number of patients with an improvement in OHIP summary scores is shown in Table 4. The percentage of patients who showed improvement after treatment was 72.5 %, which was almost the same as that in the single- and two-unit groups. When using the MID of 6 points as the index, 63.6 % of the single-unit group and 58.6 % of the two-unit group showed an improvement of 6 points or more.

**Table 1** Patient characteristics and implant-related parameters.

		Single-unit group (N = 11)	Two-unit group (N = 29)	P-value
Age (mean ± standard deviation)		63.2 ± 12.7	59.8 ± 9.7	0.366 <sup>a</sup>
Sex	Female	4	18	0.173 <sup>b</sup>
	Male	7	11	
Jaw	Upper	4	7	0.455 <sup>b</sup>
	Lower	7	22	
Implant manufacturer	Straumann®	10	18	0.130 <sup>b</sup>
	Nobel Biocare™	1	10	
Bone graft	Yes	6	7	0.128 <sup>b</sup>
	No	5	22	
Crown material	Monolithic zirconia	11	23	0.162 <sup>b</sup>
	Porcelain-fused-to-metal	0	6	
Retention type	Screw-retained	11	28	>0.999 <sup>b</sup>
	Cement-retained	0	1	

<sup>a</sup> Student's *t*-test.<sup>b</sup> Fischer's exact test.**Table 2** Pre- and post-treatment comparisons.

	Pre-treatment	Post-treatment	P-value	Effect size
All patients (N = 40)				
OHIP summary score	34.5 (18.0–54.3)	17.0 (3.3–36.0)	<0.001 *	0.604
Oral Function score	7.0 (3.3–11)	3.0 (0–7.0)	<0.001 *	0.569
Orofacial Appearance score	4.0 (2.0–7.5)	1.0 (0–4.0)	<0.001 *	0.662
Orofacial Pain score	6.0 (2.0–9.0)	3.0 (0–7.0)	0.002 *	0.544
Psychosocial Impact score	6.0 (1.3–15.8)	2 (0–12.8)	0.032 *	0.362
Glucose concentration (mg/dL)	233.5 (200.0–312.3)	259.0 (233.0–361.0)	0.009 *	0.399
Single-unit group (N = 11)				
OHIP summary score	33.0 (18.0–51.0)	27.0 (4.0–39.0)	0.168	0.481
Oral Function score	10.0 (4.0–12.0)	6.0 (0–7.0)	0.018 *	0.740
Orofacial Appearance score	5.0 (2.0–9.0)	3.0 (1.0–4.0)	0.039 *	0.590
Orofacial Pain score	6.0 (2.0–8.0)	6.0 (1.0–7.0)	0.065	0.603
Psychosocial Impact score	6.0 (1.0–19.0)	4.0 (0–15.0)	0.623	0.220
Glucose concentration (mg/dL)	298.0 (207.0–409.0)	334.0 (246.0–406.0)	0.320	0.305
Two-unit group (N = 29)				
OHIP summary score	35.0 (16.5–56.0)	15.0 (3.0–35.0)	0.004 *	0.633
Oral Function score	7.0 (3.0–11.0)	3.0 (0–7.5)	0.021 *	0.510
Orofacial Appearance score	4.0 (2.0–7.0)	1.0 (0–4.0)	<0.001 *	0.670
Orofacial Pain score	6.0 (1.5–9.5)	2.0 (0–7.0)	0.065	0.550
Psychosocial Impact score	6.0 (1.5–15.5)	2.0 (0–11.0)	0.053	0.422
Glucose concentration (mg/dL)	223.0 (189.0–291.5)	252.5 (222.8–301.5)	0.004 *	0.442

\**P* < 0.05. Data are presented as the medians (lower to upper quartiles). *P*-values were calculated using the Wilcoxon signed-rank test. Cohen's *d* with Hedges' correction is shown as the effect size. OHIP, Oral Health Impact Profile.

**Table 3** Comparison of the changes in the Oral Health Impact Profile scores and gummy jelly glucose concentration between the single- and two-unit groups.

	Single-unit group (N = 11)	Two-unit group (N = 29)	P-value
OHIP summary score changes	−15.0 (−27.0–2.0)	−8.0 (−33.0–0)	0.682
Oral Function score changes	−4.0 (−8.0–0)	−4.0 (−6.0–0.5)	0.750
Orofacial Appearance score changes	−1.0 (−4.0–0)	−2.0 (−5.0–0)	0.592
Orofacial Pain score changes	−2.0 (−4.0–0)	0 (−6.5–0)	0.902
Psychosocial Impact score changes	−1.0 (−8.0–7.0)	−1.0 (−8.5–0)	0.861
Glucose concentration changes (mg/dL)	39.0 (−51.0–134.0)	40.0 (2.0–108.0)	0.751

Data are presented as the medians (lower to upper quartiles) of the pre-to post-treatment changes. *P*-values were calculated based on the Mann–Whitney *U* test. OHIP, Oral Health Impact Profile.

**Table 4** Changes in the Oral Health Impact Profile summary score.

	All patients N = 40	Single-unit group N = 11	Two-unit group N = 29
Better OHIP score post- than pre-treatment	29 (72.5 %)	8 (72.7 %)	21 (72.4 %)
Good effect (OHIP change $\leq -6$ )	24 (60.0 %)	7 (63.6 %)	17 (58.6 %)
No effect (OHIP change $-5$ to $5$ )	11 (27.5 %)	2 (20.0 %)	9 (31.0 %)
Poor effect (OHIP change $\geq 6$ )	5 (12.5 %)	2 (18.2 %)	3 (10.3 %)

OHIP, Oral Health Impact Profile.

## Discussion

In this study, patients showed significant improvement in the OHIP summary score, four-dimensional scores, and masticatory performance after IFPD treatment, indicating that IFPD treatment improves OHRQoL and objective masticatory function.

A previous study of two-unit IFPD treatment effect in 20 patients with two adjacent missing posterior mandibular teeth (Kennedy Class II, 75 %; Class III, 25 %) reported that the OHIP-14 summary score<sup>23</sup> was significantly improved with a 60 % reduction (from 24.60 to 9.94) between pre-treatment and 2–3 months after IFPD placement.<sup>10</sup> Another IFPD study including 36 patients with 1–3 missing teeth in the molar region (including Kennedy Class II and III) reported a significant improvement with a 47 % reduction in the OHIP-49 summary score (from 44.3 to 23.3) 1 month after IFPD placement.<sup>11</sup> OHRQoL, as measured by the OHIP score, may improve with IFPD treatment, possibly increasing occlusal support in the partially edentulous dentition. Our study, exclusively focusing on the patients with SDA having Kennedy Class II partially edentulous dentition with two adjacent missing molars, revealed a significant improvement of 50 % in the OHIP-49 summary score following IFPD treatment, similar to that of published studies.

The effect size using Cohen's *d* with Hedges' correction for pre- and post-treatment changes was moderate for the OHIP summary score ( $d = 0.604$ ) and dimension scores of *Oral Function*, *Orofacial Appearance*, and *Orofacial Pain* ( $d = 0.569$ ,  $0.662$ , and  $0.544$ , respectively), and small for the *Psychosocial Impact* dimension score ( $d = 0.362$ ).<sup>13</sup> Effect size is acceptable and clinically meaningful at 0.5 or greater.<sup>24</sup> In a study including 36 patients with 1–3 missing premolar/molars (including Kennedy Class II and III),<sup>11</sup> the effect sizes (Cohen's *d* without Hedges' correction) were slightly larger than those in our study. The large effect size of the OHIP summary score and *Orofacial Appearance* dimension score reported in that study<sup>11</sup> may be because the study participants included those with missing premolars, and the effect size reflected the magnitude of the esthetic influence on the OHIP score. In our study, the esthetic influence tended to be smaller because we restricted the edentulous pattern to missing molars. While the effect size of the *Oral Function* score was moderate ( $d = 0.569$ ), that of glucose concentration as an objective masticatory function was low ( $d = 0.399$ ). Montero et al. found the subjective assessment method to be more effective in detecting changes in masticatory function than the objective assessment method.<sup>25</sup>

Considering the effect size, our study showed that the patient-reported outcome measure using the OHIP was more responsive than the objective measure of masticatory function using the gummy jelly method, which is consistent with the results of Montero et al.<sup>25</sup> When divided into two groups for analysis, significant improvements in *Oral Function* and *Orofacial Appearance* were observed in both the single- and two-unit groups. A previous report has shown that patients who underwent IFPD treatment with the expectation of functional and esthetic changes experienced satisfaction that exceeded these expectations.<sup>26</sup> This study demonstrated the functional and esthetic contributions of IFPD treatment in patients with two adjacent missing molars, regardless of the number of teeth restored. Overall, this study should be regarded as the first study that demonstrated the effect of IFPD treatment on OHRQoL in patients with unilateral SDA missing two molars.

The choice of implant-related parameters, such as implant manufacturer, materials used for the superstructure, and retention type, were determined on a case-by-case basis (Table 1), but their effects on OHRQoL were not investigated. When interpreting the results of this study, it should be acknowledged that although most of these parameters have been reported to have no significant effect on the overall survival of IFPDs,<sup>15,16,27</sup> they may be involved in the development of certain complications that have the potential to impair OHRQoL.

Comparing the single- and two-unit groups, the effect size of the OHIP summary score was small ( $d = 0.481$ ) in the single-unit group and moderate ( $d = 0.633$ ) in the two-unit group. No statistically significant differences were observed between the groups in pre- and post-treatment changes in the OHIP summary score, each dimension score, or glucose concentration. In terms of MID, both groups improved their OHIP scores by more than 6 points, with 63.6 % of the single-unit group and 58.6 % of the two-unit group showing an improvement of at least 6 points; however, no clear differences were observed between the groups. Therefore, the second null hypothesis is not rejected. However, the number of patients in the single-unit group was small, as the study focused primarily on a pre- and post-treatment comparison in patients with SDA missing two adjacent molars. Hence, the lack of significant differences between the groups in Table 3 may be attributed to an insufficient sample size, which should be regarded as one of the study's limitations. Further investigation with a larger sample size of patients may be warranted. Besides, this study underwent a post-treatment OHIP evaluation 1 month after the placement of the final IFPDs, indicating a short follow-up period,



which is acknowledged as another study limitation; therefore, longer follow-up periods are needed in future studies.

In conclusion, within the above-mentioned limitation, IFPD treatment for patients with SDA missing two adjacent molars may lead to clinically meaningful improvements in OHRQoL, regardless of the number of teeth restored.

## Declaration of competing interest

The authors declare no competing interests relevant to this article.

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