

# Effect of Removable Partial Dentures on Masticatory Performance and Oral Health-related Quality of Life in Shortened Dental Arch Patients

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## ABSTRACT

**Aim and objective:** This study aimed to evaluate the effect of removable partial dentures (RPDs) on masticatory performance (MP) and oral health-related quality of life (OHRQoL) in shortened dental arch (SDA) patients.

**Materials and methods:** Twenty mandibular SDA patients with four occlusal units, opposing with maxillary complete dentition, that were natural teeth or fixed prosthesis, were recruited and measured MP by using gummy jelly (Glucolumn, GC Co. Ltd., Tokyo, Japan) and Glucosensor GS-II (GC Co. Ltd., Tokyo, Japan) (glucose extraction method). In addition, OHRQoL was assessed by using the oral health impact profile-14 questionnaire, which consists of 14 questions with seven domains. The total score and individual domain scores were calculated and used as parameters of OHRQoL. At 2 weeks after the final adjustment of RPD, MP and OHRQoL were assessed by the same method and questionnaire. These data were compared before and after rehabilitation. The  $p$  value of  $<0.05$  was considered statistically significant.

**Results:** A total of 20 SDA patients consisting of 17 (85%) females and 3 (15%) males who met the prescribed criteria (45–68 years, mean;  $56 \pm 8.23$  years) were recruited. Both MP ( $p < 0.001$ ) and OHRQoL ( $p < 0.001$ ) were significantly improved after rehabilitation.

**Conclusion:** These results suggested that rehabilitation with RPDs significantly improves objective MP and subjective OHRQoL in patients with SDA.

**Keywords:** Glucose extraction method, Masticatory performance, Oral health-related quality of life, Rehabilitation, Removable partial denture, Shortened dental arch.

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## INTRODUCTION

By the year 2050, the percent of the elderly (60 years and over) is projected to more than double, with over 1.5 billion in the elderly population.<sup>1</sup> Accompanying this, an increasing number of people are retaining their teeth into old age and becoming partial edentulism.<sup>2</sup> In particular, posterior teeth are relatively at increased risk of loss, due to difficulty in performing efficient oral hygiene and the substantial amount of occlusal force in this area.<sup>3</sup> A state of partial edentulism where the most distal teeth are missing is referred to as a shortened dental arch (SDA).<sup>4</sup> Depending on the degree of shortening, SDA can be classified into four categories: (1) slightly SDA with 5–7 occlusal units (OUs), (2) moderately SDA with 3–4 OUs, (3) extremely SDA with 0–2 OUs, and (4) asymmetrical extremely SDA with no premolar occlusion on one side and more occluding pairs on the other side.<sup>5</sup> An occluding pair of premolars means one OU, and an occluding pair of molars means two OUs.<sup>4</sup> Possible implications of partial edentulism include masticatory inefficiency, changes in food selections, psychosocial problems, and decreased oral health-related quality of life (OHRQoL).<sup>6</sup>

One of the important goals of prosthodontic rehabilitation in partially edentulous patients is to restore masticatory function because the chewing ability is important both for oral health and the general health status.<sup>7</sup> When tooth replacement is required for patients with SDA, cantilevered fixed prostheses, implant-supported fixed prostheses, implant-supported/retained removable partial dentures (RPDs), and conventional cast RPDs can be considered. Rehabilitation with RPDs is the most common option because it is relatively simple, non-invasive, and inexpensive while it

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has high caries risk and periodontal destruction of abutment teeth (high biological cost).<sup>8</sup> Therefore, another alternate option is the use of the SDA concept. In 1981, Kayser<sup>4</sup> suggested that restoration of missing posterior teeth should be performed to the level of the functional dentition (second premolars) in older individuals, ideally in symmetric SDA patients with at least four OUs, because of their sufficient adaptive capacity to maintain adequate oral function. Therefore, the World Health Organization has proposed this concept as an adult oral health goal till the end of life.<sup>9</sup> In addition, this concept is corroborated by observational studies related to occlusal stability, signs and symptoms of mandibular

dysfunction, oral function, oral comfort, and periodontal support in SDA patients.<sup>10</sup> Nonetheless, this concept has been rejected by some studies on SDA in relation to temporomandibular joint dysfunction,<sup>11</sup> increased risk to lose premolars,<sup>12</sup> and brain activity.<sup>13</sup>

Not restoring SDA with distal extension RPD is due to the possible risk for abutment teeth deterioration, rather than providing clinically relevant posterior occlusal support, and perceived limited added value accounting for not wearing the RPD.<sup>14–16</sup> On the other hand, it has been criticized because posterior teeth loss is related to a decrease in masticatory performance (MP), mandibular displacement,<sup>3</sup> as well as various changes in the body. Masticatory inefficiency is believed to cause deficiencies in nutrition with various effects on general health and a preference for a more soft diet than vegetables.<sup>17,18</sup> In addition, soft-diet feeding associated with masticatory deficiency due to tooth loss is a risk factor for the development of dementia and Alzheimer's disease.<sup>19</sup> Thus, restoring SDA with RPD is to improve masticatory function and to re-establish the posterior occlusal support.<sup>20,21</sup>

Nevertheless, the SDA concept is still a controversial issue. In the case of a patient who seeks the restoration of lost molars, whether to replace or better not to replace is in doubt for most of the clinicians. Therefore, it was hypothesized that removable cast partial dentures for SDA patients improve MP and OHRQoL. This study aimed to evaluate the effect of distal extension RPDs on MP and OHRQoL in SDA patients.

## MATERIALS AND METHODS

This quasi-experimental study was carried out in the Department of Prosthodontics, between September 2019 and August 2020. A total of 20 mandibular partially edentulous patients were recruited consecutively according to the selection criteria as shown in Table 1. The sample size calculation was performed based on a previous study of similar nature in which a sample size with sufficient statistical power was achieved with 18 participants.<sup>22</sup> Therefore, for statistical analysis and comparison for probable dropout, the total sample size was 20 (typical dropout percentage

of 10%). This study was conducted after approval of protocol from the Board of Study (Prosthodontics) and the Research and Ethics Committee.

During the study period, informed consent was obtained from all patients participating in this study after a thorough explanation of the study procedure in accordance with the Declaration of Helsinki. Sociodemographic conditions such as age, sex, time of edentulism, and denture experience were collected at the time of evaluation. And then, MP and OHRQoL were assessed as a baseline evaluation.

All clinical and laboratory procedures were performed according to the standardized methods and principles used in the Department of Prosthodontics, in accordance with the standard operative procedure for infection control during the coronavirus disease 2019 pandemic. Each subject received conventional mandibular cast RPDs (Kennedy Class I or Class II) with artificial teeth up to second molars and the acrylic resin base extension up to the retromolar pad. At 2 weeks, after the final adjustment of RPD, MP, and OHRQoL were assessed by the same procedure. The data were recorded and compared between before rehabilitation and after rehabilitation.

Assessment of MP score was done by the glucose extraction method using cylindrical shaped gummy jelly (Glucocolumn, GC Co. Ltd., Tokyo, Japan) and Glucosensor GS-II (GC Corporation, Tokyo, Japan).<sup>23,24</sup> The validity, reliability, and reproducibility of this method have been reported previously.<sup>25,26</sup> The subjects were requested to chew the gummy jelly on their habitual chewing side with all efforts for 20 seconds. Then, the participants were asked to take 10 mL of distilled water in their mouth, and to expectorate all the bolus and water into a filter cup from top of the mesh. Then, the mesh was immediately removed and the cup was lightly agitated for 10 seconds to make it uniform. Following this, the disposable collection brush was sufficiently impregnated with the filtrate and then it was dropped on a GS-II sensor chip. The concentration of the dissolved glucose (mg/dL) in the filtrate was considered as MP score. The glucose concentrations from three trials were averaged for each participant for statistical analyses.

To measure OHRQoL, oral health impact profile (OHIP-14) questionnaires were used. The OHIP-14 questionnaire has 14 items with seven domains derived from the OHIP-49 which is a 49-item questionnaire.<sup>27</sup> It has been previously validated.<sup>28,29</sup> Subjects were asked how frequently they had encountered the impact of each item in the last month. Responses were made on a scale of 0 (never) to 4 (very often). Total scores and individual domain scores were calculated by summing all these scores from 14 questions without weighting. A total score of 56 is the highest and it means OHRQoL is the lowest. The lower the total OHIP scores, the better the OHRQoL outcomes are. The same questionnaires were administered by a research nurse before and after rehabilitation. In this study, the summary score of 14 items and individual domain scores were used as indices for OHRQoL.

Data entry and analysis were done by Statistical Package for Social Sciences (SPSS, v25.0; IBM Corp., Armonk, NY, USA). Normality was checked by the Kolmogorov–Smirnov test. As the data were normally distributed, a paired *t*-test was used for within-group comparisons. The effect size (ES) for the MP score and the OHIP summary score were calculated with the following function: (mean score after rehabilitation–mean score before rehabilitation)/standard deviation (SD) of change score. The ES <0.2 is considered

**Table 1:** Inclusion and exclusion criteria

Criteria
Inclusion criteria
<ul style="list-style-type: none"> <li>• Age–45–70 years</li> <li>• Gender–Both sexes</li> <li>• Partially edentulous mandible:               <ul style="list-style-type: none"> <li>• With 4 occlusal units (An occluding pair of premolars means one occlusal unit, and an occluding pair of molars means two occlusal units)</li> <li>• Intact anterior region or restorable with conventional fixed prostheses/implant-supported fixed prostheses</li> <li>• Those opposing with complete maxillary dentition (excluding third molars) that were natural teeth or fixed prosthesis</li> </ul> </li> </ul>
Exclusion criteria
<ul style="list-style-type: none"> <li>• Acute dental and periodontal diseases</li> <li>• Patients who had any signs or symptoms of temporomandibular joint disorders</li> <li>• Patients with mandibular torus</li> <li>• Patients with uncontrolled diabetes mellitus</li> </ul>

to be small, 0.4 is moderate, and  $>0.8$  is large.<sup>30</sup> The level of significance was set at a  $p$  value of  $<0.05$ .

## RESULTS

A total of 20 mandibular SDA patients who met the prescribed criteria were recruited (45–68 years, mean age;  $56 \pm 8.23$  years) during the study period. Of these subjects, 85% (17/20) were females and 15% (3/20) were males. The demographic characteristics of the patients were presented in Table 2. The MP after rehabilitation was significantly better than before rehabilitation (Table 3). The total and individual domain scores of OHIP-14 after rehabilitation were significantly lower than before rehabilitation (Table 4). The result of the within-subject comparison found large and statistically significant improvements in both MP (ES = 1.22,  $p < 0.001$ ) and OHRQoL (ES =  $-1.56$ ,  $p < 0.001$ ) after rehabilitation with RPDs.

**Table 2:** Demographic characteristics of the subjects ( $n = 20$ )

Demographic characteristics	
Age (years) <sup>#</sup>	56 (8.23)
Gender <sup>§</sup>	
Male	3 (15)
Female	17 (85)
Time of edentulism (years) <sup>#</sup>	10.34 (10.78)
Denture experience <sup>§</sup>	
Presence	6 (30)
Absence	14 (70)

<sup>#</sup>mean (SD), <sup>§</sup> $n$  (%)

**Table 3:** Mean values and standard deviations of masticatory performance before and after treatment ( $n = 20$ )

Masticatory performance (mg/dL)			
Mean (SD)			
Before rehabilitation	After rehabilitation	$t$ statistics (df)	$p$ -value <sup>†</sup>
130.80 (26.78)	177.48 (38.76)	$-5.456$ (19)	$<0.001^*$

<sup>†</sup>Paired  $t$  test

\* $p < 0.001$

**Table 4:** Mean and standard deviations for total score and individual domain scores with 7 domains before and after rehabilitation ( $n = 20$ )

	OHIP score: Mean (SD)			
	Before rehabilitation	After rehabilitation	$t$ statistics (df)	$p$ value <sup>†</sup>
Total score of OHIP-14	15.85 (8.96)	4.20 (4.21)	6.993 (19)	$<0.001^{***}$
Domain				
• Functional limitation	0.80 (1.40)	0.35 (0.67)	1.484 (19)	0.154
• Pain	4.00 (1.75)	1.60 (1.43)	4.857 (19)	$<0.001^{***}$
• Psychological discomfort	2.45 (2.09)	0.90 (1.02)	3.538 (19)	0.002**
• Physical disability	3.45 (2.24)	0.30 (0.92)	7.416 (19)	$<0.001^{***}$
• Psychological disability	1.90 (2.05)	0.70 (1.26)	3.335 (19)	0.003**
• Social disability	1.75 (1.71)	0.10 (0.31)	4.714 (19)	$<0.001^{***}$
• Handicap	1.50 (1.54)	0.25 (0.64)	3.526 (19)	0.002**

<sup>†</sup>Paired  $t$  test

\*\* $p < 0.01$ , \*\*\* $p < 0.001$

## DISCUSSION

The present study aimed to evaluate whether rehabilitation with RPDs in SDA patients could improve MP and OHRQoL. This study found that rehabilitation with RPD is an effective treatment option for mandibular SDA patients in terms of MP (objectively) and OHRQoL (subjectively).

The result of the within-subject comparison showed a statistically significant improvement in mean MP score from before rehabilitation to after rehabilitation ( $p < 0.001$ ) indicating that rehabilitation with RPDs in mandibular SDA patients possibly improved objective MP by providing balanced occlusion. This result could be attributed to the presence of more functional tooth units to preserve the masticatory function after the replacement of missing posterior teeth.<sup>31</sup> This finding is consistent with the previous studies, where treatment with RPD significantly improved MP.<sup>13,32–34</sup> However, it is contrary to other studies where there was no significant difference in MP before and after rehabilitation with RPD.<sup>35,36</sup> The variation in methods for assessing MP employed in these studies and the different study designs may be responsible for this discrepancy. For many years, Manly's sieving method has been used as a standard diagnostic method for MP, where a test food was chewed for a specified number of strokes, and then the bolus is retrieved from the oral cavity before measuring with sieves of various mesh sizes. However, this method is plagued with issues related to complicated manipulations and the time-consuming nature. Therefore, alternative straightforward strategies have been introduced utilizing silicone impression material, paraffin wax, chewing gum, or gummy jelly as the test foods. In the present study, the glucose extraction method was used because it is relatively simple and possible to standardize the properties of the gummy jelly as the test food. In addition, there are reports of positive correlations between the MP as measured by this method and that measured by the sieving method<sup>37</sup> as well as the mixing ability test.<sup>26</sup>

The results of this study indicated that rehabilitation with RPDs in mandibular SDA patients significantly improved their OHRQoL. This finding is consistent with the previous studies<sup>22,38,39</sup> where restoration of missing posterior teeth in SDA patients improved OHRQoL. In addition, within-subject comparison studies evaluating treatment outcomes before and after rehabilitation indicated that rehabilitation with RPDs improved OHRQoL,<sup>22,39</sup>

while between-subject comparison studies found that RPDs in SDA patients did not indicate more statistically significant improvement in OHRQoL than the treatment according to the SDA concept.<sup>38,40–42</sup> A possible explanation for these results may be the fact that only patients suffering from decreased quality of life sought prosthodontic treatments to fulfill their needs.<sup>20,22</sup>

With regard to individual domains of the OHIP-14, the present study found that there were statistically significant reductions in mean scores of all domains except functional limitation, despite a reduction from before rehabilitation (0.80 points) to after rehabilitation (0.35 points). This can be explained by the fact that the subjects have the lowest impact on functional limitation domains before rehabilitation among seven domains.

Of all the OHIP domains, the pain had the highest mean score in all participants before rehabilitation with RPDs. Among two questions regarding physical pain, patients scored impact mainly in the question concerned with “uncomfortable to eat” at pretreatment. This may be due to masticatory load and pain on mastication acting on remaining alveolar ridge and masticatory mucosa in the areas of missing posterior teeth. Therefore, difficult to eat comfortably might be the reason why they sought treatments in SDA patients.

Some researchers analyzed the effect of RPDs on OHRQoL in SDA patients using the OHIP-49. Wolfart et al. found significant improvements in all OHIP domains.<sup>38</sup> However, Fueki et al. found that significant improvements were observed in functional limitation domain and psychological discomfort domain.<sup>22</sup> In addition, Omo et al. reported that there were significant improvements in all domains of OHIP-49 except functional limitation and handicap domains after rehabilitation with mandibular RPDs.<sup>39</sup>

Moreover, the ES for MP and OHIP summary scores were estimated for benchmarks of the effect of rehabilitation with RPDs in mandibular SDA patients in this study. As the ES for both MP and OHIP summary scores were >0.8, there were large and clinically significant improvements in MP and OHRQoL after rehabilitation with RPDs. Furthermore, in terms of clinical significance, whether the treatment effect on patient perceptions is more than a minimally important difference (MID) should be considered. The concept of MID for OHRQoL has been demonstrated as the smallest score difference that subjects perceive as being advantageous.<sup>43,44</sup> Despite being not constant in various settings, to assess clinical significance in terms of patient-based outcomes, the MID in OHIP-14 summary scores (a 5-point change in OHIP-14 summary score) from previous studies was used as a norm.<sup>45,46</sup> A recent study proposed that a 3-point change in OHIP-14 summary score was clinically meaningful in RPD treatments.<sup>47</sup> In the present study, the mean change in summary score (11.65 points) is substantially larger than the proposed MID indicating that rehabilitation with RPDs in mandibular SDA patients is not only statistically significant but also clinically significant. Therefore, the results of this study suggest that rehabilitation with RPDs offers not only statistically but also a clinically significant improvement in OHRQoL in mandibular SDA patients who sought prosthetic treatments.

Although this study was designed to investigate the effect of RPD treatment both on objective MP and subjective OHRQoL in mandibular SDA patients, it has some limitations such as a small sample size with a larger participation of women and limited follow-up interval. Thus, a study with a larger sample size with equal distribution of sex and a longer follow-up period is needed to validate the conclusions of this study. A variety of positive outcomes

such as nutritional status, cost-effectiveness, the longevity of RPD, and maintenance of the health of remaining oral tissue should be considered in clinical decision-making.

## CONCLUSION

Within the limitations of this study, rehabilitation with RPDs significantly improves objective MP and subjective OHRQoL in mandibular SDA patients.

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