Swinglock Removable Partial Denture and Biting Forces in Partially Edentulous Patients

Comparison of Individual Biting Forces With and Without Swinglock Removable Partial Denture

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Abstract

Several studies have shown that swinglock removable partial dentures are effective for stability of the abutment teeth and the surrounding tissues including alveolar bone. This efficacy has been thought to be due to the dynamic structure of the swinglock attachment. Individual biting force was measured to determine the physiological efficacy of teeth splints by use of the attachment. The results showed that individual biting forces with the swinglock removable partial denture were 10-25% higher than those without the denture. Furthermore, statistical analysis showed that the individual biting forces with the swinglock removable partial denture were significantly higher. The swinglock attachment can stabilize partially edentulous dentition by splinting all residual teeth. In addition, when physical forces are applied to the abutment teeth and the artificial teeth, this attachment can deliver and distribute the stress to the other abutment teeth and alveolar mucosa. The present findings suggest that the swinglock attachment augments the ability to withstand physical forces such as those occurring during biting and mastication.

Introduction

In proper alignment, the teeth are arranged in arches in each jaw and placed in contact with their neighbors. In addition, when each tooth in the arch is placed at its most advantageous angle to withstand forces brought to bear upon it, its function is more efficient and the arches are stabilized by the collective action of the teeth in supporting each other. Thus, contact of each tooth with its neighbors in the arch protects the surrounding tissues including the gingiva and the alveolar bone. Any missing teeth result in a decrease of the bearing capability of the dentition, especially in the neighborhood of the extracted tooth, to physical forces such as those in mastication and biting. When one or two teeth are missing, patients can be treated with a fixed partial denture to restore the rigidity of the dentition by splinting the residual teeth. However, a fixed partial denture restricts the physiological mobility of the abutment teeth to a two-dimensional bucco-lingual direction. Physiological three-dimensional tooth mobility has been thought to be significant from a biological viewpoint. Therefore, the propriety of traditional fixed prosthetic treatment should be demonstrated scientifically.

We have recently studied the dynamic effect of a swinglock attachment-applied removable partial denture (S/L RPD) to elucidate the physiological influence of the tooth splint, since the S/L RPD has a unique structure for the splinting of partially edentulous dentition[1]. In this

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study, individual biting forces were measured to investigate the dynamic effectiveness of the swinglock attachment in terms of physiological forces such as those occurring during mastication and biting.

**Materials and Methods**

1. **Subjects**

Eighteen subjects, 12 men and 6 women, aged between 45 and 62 yr, were selected from patients treated with S/L RPD at the Dental Hospital of Nihon University School of Dentistry at Matsudo, and gave informed consent to participate in this study. All the subjects were free of medical complaints and overt symptoms of temporomandibular joint dysfunction.

2. **Measuring apparatus**

The biting forces were measured using a gnatho-dynamometer MPM-2401(Nihon Kohden Kogyo Co., Ltd., Tokyo) with a transducer for biting forces.

3. **Individual biting forces**

The individual biting forces were measured by a standard protocol described previously by Takamizawa. Briefly, study models were mounted on an articulator. The occlusal table of the adapter was waxed up so as to be parallel to the occlusal plane of each subject, while the upper member of the articulator was raised up to 2~3 mm in the anterior guide pin. The metal adapters were cemented to the occlusal surface or the edge of the tooth with a water-settable cement. The sequential metal adapter, which was opposite to the single metal adapter for the abutment tooth, was extended to both the mesial and distal neighborhood of the corresponding antagonist or artificial tooth of the S/L RPD. The individual biting force, the maximum biting force of each abutment tooth, was obtained by biting the stain gauge between the single metal adapter for the abutment tooth and the sequential metal adapter.

Individual biting forces of the abutment teeth were measured after 1 month with the insertion of the S/L RPD. The measurements were repeated 5 times with the S/L RPD and without the S/L RPD in each abutment tooth.

4. **Statistical analysis**

Individual biting forces with and without the S/L RPD were collected according to tooth location. The significance of differences between the individual biting forces with the S/L RPD and those without were analyzed by Student’s t test as a parametric test and by the Wilcoxon signed-rank test as a nonparametric test.

**Results**

Figure 1 shows an example of individual biting forces measured in this study. When individual biting forces were measured, an occlusal examination and a fitness test of the S/L RPD including the denture base and metal frame were carried out to confirm clinical propriety in all subjects. Furthermore, it was confirmed that all subjects had no complaints about the S/L RPD. As shown in Fig. 1, the individual biting forces with the S/L RPD were higher than those without, except for the lower lateral incisor. Furthermore, the rates of increase in individual biting forces with / without the S/L RPD were relatively higher for premolar teeth, when compared with the anterior teeth.

Table 1 shows the numbers of abutment teeth (n), minimum value (Min.), maximum value (Max.), mean, and standard deviation (SD) and the level of significance (P1, P2) of the difference between individual biting forces with and without the S/L RPD for each abutment tooth. The maxillary central incisor, maxillary lateral incisor, maxillary canine, maxillary first premolar, maxillary second premolar, mandibular central incisor, mandibular lateral incisor, mandibular canine, mandibular first premolar, and mandibular second premolar were abbreviated to U1, U2, U3, U4, U5, L1, L2, L3, L4, and L5, respectively. In addition, the individual biting forces of the incisor group (U1+U2, L1+L2), which had relatively lower individual biting forces, and
the canine and premolar group (U3+U4+U5, L3+L4+L5), which had relatively higher individual biting forces, were calculated. The probabilities analyzed by Student’s $t$ test and the Wilcoxon signed-rank test are shown in $P_1$ and $P_2$, respectively.

As shown in Table 1, every tooth and group had a relatively higher standard deviation, since the morphological and physiological factors such as the level of the alveolar bone and the musculoskeletal system, which could profoundly affect the biting forces, differed among the subjects. However, individual biting forces with the S/L RPD showed higher values for all teeth and groups compared with those without the S/L RPD. The rates of increase (individual biting forces with S/L RPD (kg) / individual biting forces without S/L RPD (kg)) were 1.06 for U1, 1.11 for U1+U2, 1.10 for U3, 1.15 for L2, 1.21 for U2, 1.23 for U4, 1.23 for U5, 1.21 for U3+U4+U5, 1.25 for L1, 1.20 for L1+L2, 1.22 for L3, 1.23 for L4, 1.22 for L5, and 1.22 for L3+L4+L5. In almost all teeth and groups, statistical analysis showed significant differences between the use of S/L RPD and without, except for U1, U2, and U1+U2, for which sample numbers were relatively few. In particular, U4, U3+U4+U5, L1, L2, L1+L2, L3, and L3+L4+L5 had a significant difference at $P < 0.001$.

![Fig. 1 Individual Biting Forces of Abutment Teeth](image)

| Table 1 Comparison of individual biting forces with and without swinglock removable partial denture |
|---|---|---|---|---|---|---|---|---|---|---|
| Maxilla | U1 | U2 | U1+U2 | U3 | U4 | U5 | U3+U4+U5 |
| n | NON | S/L | NON | S/L | NON | S/L | NON | S/L | NON | S/L |
| Min. | 5.58 | 6.80 | 5.24 | 8.46 | 3.40 | 3.74 | 3.44 | 4.90 | 8.66 | 11.80 |
| Max. | 16.14 | 16.22 | 11.74 | 12.12 | 16.50 | 18.30 | 24.80 | 32.36 | 30.28 | 41.10 |
| Mean | 11.09 | 11.79 | 8.49 | 10.29 | 10.05 | 11.19 | 10.81 | 11.85 | 12.81 | 15.81 |
| SD | 5.30 | 4.74 | 4.60 | 2.59 | 4.62 | 3.68 | 4.01 | 4.41 | 6.72 | 7.92 |
| $P_1$ | 0.018 | 0.001 | <0.001 | 0.012 | 0.012 | 0.004 | 0.001 |
| $P_2$ | 0.014 | 0.006 | 0.001 | 0.004 | 0.004 | 0.001 | 0.001 |

| Mandible | L1 | L2 | L1+L2 | L3 | L4 | L5 | L3+L4+L5 |
| n | NON | S/L | NON | S/L | NON | S/L | NON | S/L |
| Min. | 2.26 | 2.92 | 2.46 | 2.12 | 4.60 | 6.08 | 7.50 | 7.84 |
| Max. | 15.78 | 16.10 | 16.72 | 17.42 | 24.52 | 26.44 | 32.34 | 37.74 |
| Mean | 6.14 | 7.70 | 7.21 | 8.26 | 6.63 | 7.95 | 10.44 | 12.69 |
| SD | 2.87 | 3.18 | 3.76 | 3.88 | 3.33 | 3.51 | 5.51 | 6.13 |
| $P_1$ | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| $P_2$ | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | 0.002 | 0.004 | <0.001 |

- $P_1$: Parametric Test
- $P_2$: Non-Parametric Test
- -: Not Determined
Discussion

In 1970, SPRIGG\cite{4} reported a 6-year clinical investigation of the prognosis of patients treated with swinglock-attachment partial dentures. He suggested that the S/L RPD could give the longest life for abutment teeth compared with other conventional partial dentures. Several clinical reports on the S/L RPD\cite{4-6} indicated that the treated patients showed a clinically good status, although these studies covered only a few years after treatment with the S/L RPD. Recently, we reported that the S/L RPD was effective for stability of the abutment teeth and surrounding tissues such as alveolar bone in a long-term clinical evaluation\cite{7}. After treatment with the S/L RPD, patients had to be given other dental treatments such as root canal treatment, restoration of the abutment teeth, and relining of the denture base. However, it was noted that the S/L RPD functioned well even 18 years after insertion. In addition, the surrounding tissue such as alveolar bone showed no involution upon X-ray examination. This effect would be based upon the tooth splinting by the swinglock attachment and its unique dynamic structure, which is distinct from other conventional dentures including conus dentures.

This study showed that the individual biting forces with the S/L RPD were significantly higher than those without. Furthermore, it was demonstrated that the individual biting forces with the S/L RPD were 10-25% higher than those without. The splinting by the swinglock attachment would reinforce the dynamic relationship of tooth contact in partially edentulous dentition. When physical forces were loaded on the abutment teeth and artificial teeth, this attachment could deliver and distribute the stress to the other abutment teeth and the alveolar ridge via the clasps and metal frame. Thus, this study suggests that the swinglock attachment can augment the ability to withstand physical stress such as biting forces.

Some studies have analyzed a mechanical simulation model of tooth and alveolar bone using the three-dimensional finite element technique\cite{8,9}. It was indicated that the periodontium supporting force decreased markedly according to the number of abutment teeth which were fixed with resin-bonded restorations. Furthermore, increased numbers of abutment teeth were required to stabilize the mobility according to alveolar bone absorption.

These findings suggest that the tooth splint would markedly affect the mobility in patients with mild to moderate alveolar bone absorption such as the subjects in this study.

Recent electromyographic studies of muscle activity have indicated that mechanical stimulation of the peripheral mechanoreceptors situated in the periodontium, alveolar mucosa, alveolar bone, elevator muscles, and temporomandibular joint influence the reflex system of jaw movement via afferent neurons\cite{10-13}. Rhythmic jaw movements such as chewing are largely programmed or preprogrammed and involve learning, which reduces the need for peripheral sensory input. However, input from peripheral mechanoreceptors still has important functions, especially in relation to learning new experiences, and protective reflexes. One advantage of treatment with the S/L RPD is to be able to keep the abutment tooth intact. Consequently, the anterior guidance for jaw movement peculiar and innate to each patient can be maintained. A technique of occlusal treatment to produce functional anterior guidance has not yet been established. It appears that it is important to accomplish prosthetic treatment to protect functional anterior guidance in patients without symptoms of mandibular dysfunction. With regard to this point, the S/L RPD has an advantage for creating stability of mandibular movement, compared with other types of denture.

The significance of the S/L RPD for long-term stability of the gnathodynamic structural elements should be addressed from a biological viewpoint. In addition, neuronal mechanisms should be elicited for updating masticatory movements with information about factors such as masticatory forces and the state and location of the bolus.
Conclusions

This study focused on the physiological responsiveness of residual teeth against biting forces by splinting of partially edentulous dentition. Individual biting forces were measured to elicit the effect of splinting by the S/L RPD. The conclusions were as follows:
1. The individual biting forces of the splinted abutment teeth with the swinglock removable partial denture were clearly higher than those without the denture.
2. The individual biting forces varied with the difference in alveolar bone level among the subjects. However, statistically significant differences were noted between individual biting forces with the S/L RPD and those without.
3. It was suggested that the dynamic effect generated from the unique structure of the swing-lock attachment could augment the individual biting forces.

References