ABSTRACT

Aim
In the present study, we evaluated the effect of implant retainers at the free-end region of removable dentures on occlusal force and masticatory efficiency using a pressure-sensitive sheet, and measured glucose concentration in saliva after mastication with gummy candy.

Methodology
In the present study, the occlusal force and masticatory efficiency of 13 subjects were measured in the following three conditions: without dentures (Condition 1), wearing dentures but not supported by implants (Condition 2), and wearing dentures supported by implant supported removable partial denture (ISRPD) (Condition 3). All data were statistically compared.

Results
Regarding the occlusal force, Condition 3 showed significantly higher scores than the other conditions; however, there were no significant differences between Conditions 1 and 2. Regarding the masticatory efficiency, Condition 3 showed significantly higher scores than Condition 2.

Conclusion
With ISRPD, the occlusal force and masticatory efficiency were increased in comparison with those with conventional removable dentures.

**Keywords** Implant-supported removable partial denture, Occlusal force, masticating efficiency.

**INTRODUCTION**

The continual resorption of the residual ridge negatively impacts the stability, retention and support of RPDs, thus placing patients in a loop of continual change towards inferior stability and discomfort. Furthermore, bone loss on the alveolar ridge also modifies the occlusal conditions most notably in the distal-extension of RPDs, thus further contributing to bone loss by causing premature contacts and uneven occlusal forces. Kelly was one of the first to report cases of patients with an edentulous maxilla rehabilitated by a complete denture opposing a Kennedy Class I defection lower arch. In all cases, it was demonstrated that the free-end RPDs led to gradual and continual bone loss in the alveolar ridge under the base of RPDs causing changes in the occlusal planning and thereby creating anterior teeth overload. This condition, where overload contributes to the resorption of anterior area and changes the force and position of mandibular teeth, has since been termed ‘Kelly’s syndrome’. To prevent the rotational movements of RPDs, precise attachments or telescope systems have been used on the remaining teeth, and an altered cast technique has been applied to offset different displacement between the remaining teeth and soft tissues during function. These studies have led to the discovery and innovation of many new systems used to treat class I Kennedy deflections in the mandible. It was also shown by other research groups that implant support helped prevent the displacement of distal extension RPDs and decreased pressure on soft tissues, thus preventing bone loss in the alveolar ridge. Furthermore, it was demonstrated that implants maintain the integrity of the vertical occlusion dimension which was a very common pattern in patients wearing conventional distal-extension removable dentures. Thus, with numerous studies demonstrating positive long term results following implant supported RPDs, it has now been demonstrated in 15-year long-term follow-up studies that implant supported removable partial denture (ISRPD) can be used with predictable long-term results in carefully selected and well-maintained patients. Patients should naturally be emphasized of their role in maintenance especially regarding implant care and a comprehensive recall system is necessary to obtain satisfactory long-term results. With the cuspid or first bicuspid as most distal tooth, the position of the implant in the edentulous zone is more or less optional and at the discretion of the prosthodontist or surgeon. Little evidence is available with respect to functional and clinical outcomes on which to base the decision. Theoretical models indicate that a more posterior position, that is, at the position of the first or second molar, reduces the pressure to soft tissues and alveolar bone the most, whereas an implant positioned directly distal to the remaining dentition reduces the stress on the abutment teeth. Recent proposals introduce that the implant-assisted removable partial denture has been applied strategically to a place with favorable bone support in partially edentulous or fully edentulous patients and use implant-supported fixed prosthesis as a partial denture abutment to fabricate the traditional partial denture. The use of the implant surveyed bridge as an abutment for partial denture increases the stability of the denture through a small number of implants while having the function and esthetic merit of the fixed prosthesis, which could enhance the clinical outcome and patient satisfaction.

**AIM OF THE PRESENT STUDY**
In the present study, we investigated the clinical effectiveness of ISRPD regarding occlusal force and masticating efficiency.

**METHODOLOGY**

Twenty-three patients participated in the present study. All participants had free-end missing dentition in either the upper or lower jaw and had removable dentures. Nine patients bilaterally received implants, and fourteen patients unilaterally received implants. All patients who satisfied these conditions and wanted to have ISRPD treatment were enrolled in the present study. The research protocol was approved by the ethics committee. A pressure-sensitive sheet, was used to measure the occlusal force. By biting this sheet, contact points between maxillary and mandibular teeth break the embedded microcapsules, releasing the contained dye. These contact points are, therefore, indicated in shades of red (dark red represents strong contact).

Total occlusal force and the occlusal forces in the denture and tooth regions were measured, and the average values of three sheets in each condition were compared. To measure the masticating efficiency, gummy candy (Glucolumn, GC) was masticated for 20 s, followed by a rinse with 10 cc of water for a couple of seconds. The rinse was expelled, collected, and evaluated using a glucose-measuring device (Glucosensor, GC) to measure the amount of glucose in the solution. For multiple comparisons, one-way analysis of variance (ANOVA) and a post hoc Tukey test for pairwise comparisons were employed. A paired t-test was used for the comparison of two data sets. A value of \( p < 0.05 \) was considered to be statistically significant.

**RESULTS**

Average total occlusal force in Conditions 1 (without denture), 2 (with denture without implant retention), and 3 (ISRPD) was 231.1, 240.3, and 398.0 N, respectively. (Table 1) Condition 3 showed significantly higher total occlusal force than that of the others, but there was no significant difference between Conditions 1 and 2. The average occlusal force at the denture area in Conditions 2 and 3 was 93.7 and 253.3 N, respectively. ISRPD showed significantly higher occlusal force at the denture area than that of removable partial dentures without implant retention. Average occlusal force at the tooth area in Conditions 1, 2, and 3 was 231.1, 146.5, and 133.8 N, respectively. Condition 1 showed a higher score than that of the others, but there were no statically significant differences. Average glucose concentrations in Conditions 2 and 3 were 166.8 and 213.1 mg/dL, respectively. There was a statistically significant difference between them. (Table 2)

**DISCUSSION**

In in vitro studies dealing with Kennedy class I or II situations, it has been demonstrated that positions more to the posterior reduce the pressure on the alveolar ridge and hence the peristome more favorably in comparison to situations where implants are positioned more to the anterior.\(^{18}\) In situations with molar support the least amount of displacement of the mucosal tissues under load is seen.\(^{19}\) It is well documented that implants placed at the distal extension of the denture base will minimize the resultant denture displacement. However, there are great differences in settling during a chewing load between the implant and mucosa under the denture base.\(^{13}\) To protect implants from excessive force, stress-breaking attachments have been manufactured as conventional commercial attachments.\(^{19}\) The initial retention of a mandibular Kennedy class I implant-assisted removable partial denture retained by two stud attachment systems indicates its clinical predictability and performance and influences patient
acceptance. However, these attachments do not fully compensate for the different amount of pressure displacement of the mucosa due to individual variations. Many different attachments may be used to connect implants such as cover screws, healing caps, stress-breaking ball attachment and O-ring attachments. Several studies have evaluated the retention of attachments in implant-retained Overdentures. Regarding total occlusal force, in the present study, ISRPD showed significantly higher values than those of the other conditions. This was similar to previously reported data. The support provided from implants may prevent the settlement of the dentures and thereby increase total occlusal force. By contrast, there was no significant difference between dentures without implant support (Condition 2) and the non-denture condition (Condition 1). This implies that total occlusal force was almost the same in these conditions, regardless of the presence or absence of conventional partial dentures. A larger total occlusal force may be the cause of the pain at the denture-bearing mucosa, and may prevent an increase in total occlusal force. In the present study, the concentration of glucose exuded from gummy candy as a consequence of grinding at the occlusion was measured and defined as masticatory efficiency. In the present study, occlusion at the molar regions varied among subjects in association with the number and distribution of the remaining teeth, and this may have been a cause for variation; thus, we did not measure masticatory efficiency without dentures. Further prospective research with a larger sample size is expected to elucidate the effect of ISRPD on occlusal performance.

CONCLUSION

It was noted that supporting free-end missing removable partial dentures with implants increased both the occlusal force and masticatory efficiency.

REFERENCES


TABLES

Table 1- Occlusal efficiency in various conditions related to ISRPD in the present study.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Total occlusal force</td>
<td>231.1 N</td>
<td>240.3 N</td>
<td>398.0 N</td>
</tr>
<tr>
<td>Average occlusal force at the denture area</td>
<td>211 N</td>
<td>93.7 N</td>
<td>253.3 N</td>
</tr>
<tr>
<td>Average occlusal force at the tooth area</td>
<td>231.1 N</td>
<td>146.5 N</td>
<td>133.8 N</td>
</tr>
</tbody>
</table>

*p≤0.05 is significant

Table 2- Masticatory efficiency in various conditions related to ISRPD in the present study.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Condition 2</th>
<th>Condition 3</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average glucose concentrations</td>
<td>141.1 mg/dL</td>
<td>166.8</td>
<td>213.1 mg/dL</td>
</tr>
</tbody>
</table>