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Pressure distribution of implant-supported removable partial dentures with stress-breaking attachments

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ABSTRACT

Purpose: This in vitro study investigated the pressure distribution of the implant-supported removable partial dentures (RPDs) with the stress-breaking attachments under the occlusal force.

Methods: The experimental model of bilateral missing premolars and molars was modified from a commercial simulation model. Five pressure sensors were embedded near the bilateral first molars, first premolars, and medio-lingual alveolar crest. Two implants were placed near the second molars, and they were connected to the denture base using the following conditions: complete separation between the denture base and implant with cover screws (CRPD), flexible connection with a stress-breaking ball (SBB) attachment, and rigid connection without stress breaking with healing caps (HC). The pressure at five different areas of the soft tissue and the displacement of the RPDs were simultaneously measured, loading up to 50 N. The coefficient of variation (CV) for each connection was calculated from all data of the pressure at five areas to evaluate the pressure distribution.

Results: The pressure on medio-lingual alveolar crest and molars of the HC was less than SBB and CRPD. In contrast, the pressure on premolars of SBB was greater than for the HC and CRPD. The CV of SBB was less than that of HC and CRPD. Denture displacement of HC and SBB was less than for CRPD.

Conclusions: Within the in vitro limitations, precise denture settlements and pressure distribution under the denture base could be controlled using an SBB attachment. An SBB attachment might be able to protect the implant from harmful force.

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1. Introduction

Distal-extension removable partial dentures (RPDs) were associated with several problems related to their limited stability, retention, aesthetics, and masticatory efficiency [1–4]. The rotational movements of RPDs might produce terminal torque forces against the abutment teeth and the soft tissue [5,6]. Ill-fitting retainers, occlusal disharmony, and pain in the soft tissue under the connector or denture base are frequently observed after long-term use [7–10]. In addition, constant pressure from the denture base gradually causes ridge resorption under the denture base [11,12].

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 tooth and soft tissue during function [13–15]. However, the rotational change of RPDs cannot be completely prevented in long-term use even if the above techniques are used. Particularly, these phenomenon are remarkably occurred for short term in the cases of Eichner classification C1 [10].

A bilateral implant placement at the distal extension of the denture base will minimize the resultant denture displacement. Consequently, less ridge resorption, fewer numbers of relining, and minimum decrease of retentive force of precision attachments would be leaded [16–18]. Moreover, the survival rate of this treatment option within 10 years is comparable to other implant therapy [19,20]. However, there are extraordinary differences in settling during a chewing load between the implant and mucosa under the denture base [21,22]. In addition, horizontal forces and rotational moments would also be applied to the implants depending on the occlusal contact, location, and number of implants in the dental arch. Therefore, excessive and harmful occlusal forces might be applied to the implant.

To protect implants from excessive force, stress-breaking attachments, such as an ERA attachment, a locater attachment, or a cushion-type magnetic attachment, have been manufactured as conventional commercial attachments. However, these attachments cannot exactly compensate for the different amounts of pressure displacement of the mucosa in individual patients [23,24].

A stress-breaking ball attachment, hereafter called ''SBB attachment,'' for implants was developed with the Department of Prosthodontics, Gerodontology and Oral Rehabilitation, Osaka University Graduate School of Dentistry to prevent excessive and harmful occlusal forces. The SBB attachment can distribute the occlusal force equally between the alveolar ridge and the implant [25]. Because these attachments are covered with a silicone housing with three amounts of space to allow three kinds of settlement, i.e., 0.3 mm, 0.5 mm, and 0.7 mm, they can be selected individually according to the thickness or pressure displacement of the mucosa and the occlusal forces. The aim of this study was to assess the differences in denture displacement and pressure distribution on the soft tissue under the denture base of a distal extension implant supported by removable partial dentures with and without stress-breaking support.

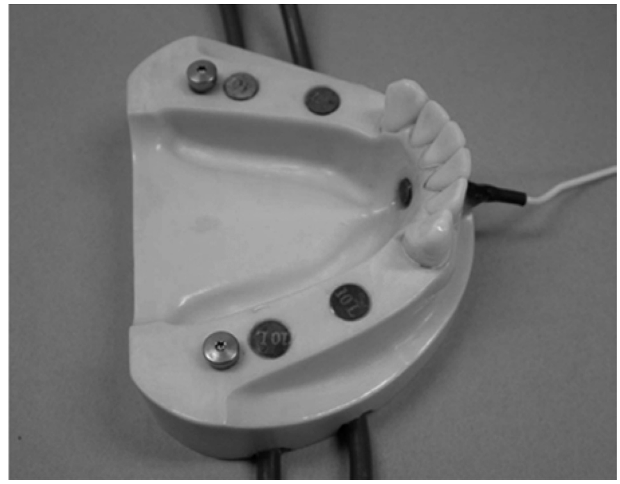

Fig. 1 – Experimental model with five pressure sensors.

Fig. 2 – Experimental bilateral metal base denture on the simulation model.

2. Materials and methods

2.1. *Preparation of simulation model*

A commercial simulation model (E50-550, Nissin, Tokyo, Japan) with mandibular bilateral missing premolars and molars was modified to prepare an experimental model. The edentulous ridge area of the commercial model was cut, and a 2-mm thickness of artificial soft tissues was created with silicone impression material (Fit Checker, GC, Tokyo, Japan). A 0.3 mm thickness of an artificial periodontal membrane of the six remaining anterior teeth was also made with the same silicone impression material (Fit Checker, GC). Five pressure sensors (PS-10K, Kyowa, Tokyo, Japan) were attached near the left and right first molars (#36 and #46), first premolars (#34 and #44), and medio-lingual alveolar crest (ML) (Fig. 1).

2.2. *Fabrication of experimental dentures*

After the definitive impression of the experimental model was taken using the silicone impression material (Exaflex, GC,