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Original article

Effects of chewing rate and reactive hyperemia on blood flow in denture-supporting mucosa during simulated chewing

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ABSTRACT

Purpose: We examined how chewing rate and the extent of reactive hyperemia affect the blood flow in denture-supporting mucosa during chewing.

Methods: The left palatal mucosa was loaded under conditions of simulated chewing or simulated clenching for 30 s, and the blood flow during loading was recorded. We compared the relative blood flow during loading under conditions that recreated different chewing rates by combining duration of chewing cycle (DCC) and occlusal time (OT): fast chewing group, typical chewing group, slow chewing group and clenching group. The relationship between relative blood flow during simulated chewing and the extent of reactive hyperemia was also analyzed.

Results: When comparing the different chewing rate, the relative blood flow was highest in fast chewing rate, followed by typical chewing rate and slow chewing rate. Accordingly, we suggest that fast chewing increases the blood flow more than typical chewing or slow chewing. There was a significant correlation between the amount of blood flow during simulated chewing and the extent of reactive hyperemia.

Conclusions: Within the limitations of this study, we concluded that slow chewing induced less blood flow than typical or fast chewing in denture-supporting mucosa and that people with less reactive hyperemia had less blood flow in denture-supporting mucosa during chewing.

1. Introduction

The mucosa under dentures is subjected to occlusal and masticatory stress transmitted through the denture base. This alters the blood flow in denture-supporting mucosa [1,2]. Continuous loading such as clenching decreases blood flow [3]. Decreased blood flow causes the deposit of metabolic products in denture-supporting mucosa of denture wearers, which

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stimulates osteoclast activity [4] and may cause pain due to the production of pain producing substances [3].

Okada et al. [5] evaluated the blood flow in denture-supporting mucosa under conditions of intermittent loading to recreate chewing. They reported that the blood flow increased under loading in 8 out of 11 subjects, but did not increase in the other 3 subjects [5]. Their results indicated that the changes in blood flow in denture-supporting mucosa during chewing varied according to the individual. However, the reason for individual variation in the blood flow during chewing is unknown. We focused on two elements that possibly contribute to the individual variation in blood flow in denture-supporting mucosa: chewing rate and reactive hyperemia.

A previous study revealed that there was an almost constant relationship between the duration of the chewing cycle (total duration of opening, closing, and occlusion phase; hereinafter called as the ''DCC'') and the occlusal time (duration of occlusion phase in the chewing cycle; hereinafter called as the ''OT'') even when the chewing rate was different [6,7]. People with low chewing rates require a longer OT because of the longer DCC. A longer OT may decrease blood flow during chewing because it causes a longer loading time on the denture-supporting mucosa.

Reactive hyperemia occurs after release of loading following continuous loading. It is a commonly used marker for vascular endothelial function. Previous studies have shown that vascular endothelial dysfunction reduces the reactive hyperemia in the limbs and gingiva [8–11]. During intermittent loading, reactive hyperemia occurs repeatedly [12]. People with low levels of reactive hyperemia may have decreased blood flow in denture-supporting mucosa during chewing.

Based on the above, we hypothesized that the chewing rate and the extent of reactive hyperemia of denture-supporting mucosa affects the blood flow under intermittent loading.

In this study, how chewing rate and the extent of reactive hyperemia affect the blood flow in the palatal mucosa under loading base during simulated chewing was examined.

2. Materials and methods

Subjects comprised 20 healthy dentulous men (mean age: 26 ± 4 years) with no missing teeth, no endermosis and/or no abnormality of the amount of tissue displacement (e.g. torus, flabby tissue) in oral mucosa. Smokers and subjects with a vomiting reflex were excluded. Female individuals were excluded because menstrual cycle could influence vascular endothelial function [13]. This study strictly conformed to the revised Declaration of Helsinki (Fortaleza) and the study protocol was approved by the Ethics Committee of Tokyo Dental College (#406).

2.1. *Experimental equipment*

Maxillary impressions were taken with a silicone impression material (Exafine, GC Corporation, Tokyo, Japan) and individual tray. The upper casts were fabricated in dental stone (New Plastone II, GC Corporation, Tokyo, Japan). The impressions of the lateral palatal area as the loading area were taken by pressure impression technique. Polyethylene terephthalate thermoplastic resin 1 mm thick (Erkodur, Erkodent, Pfalzgrafenweiler, Germany) was softened and pressed over the upper cast to fabricate a retainer and loading base fitted to the hard palate. We followed the method described by Okada et al. [5] so that the area for loading was located on the lateral aspect of the hard palate in the upper left first molar region. An opening was made in the retainer and the loading base was inserted. A non-contact, laser Doppler blood flowmeter (ALF21; Advance, Tokyo, Japan) and pressure transducer (PS-5KC; Kyowa Electronic Instruments, Tokyo, Japan) were set on center of the loading base to control the amount of loading pressure. Fig. 1 shows the upper cast with the retainer and loading base, in the shape of a circle with a radius of 8 mm (2.0 cm^2). Blood flow and loading pressure were analyzed with an analog data recording and analysis system (Power Lab 16 SP; AD Instruments, Tokyo, Japan). The fitness of the loading base for the mucosa was confirmed with a vinyl polyether material for checking fit (Fit Checker Advanced, GC Corporation, Tokyo, Japan).

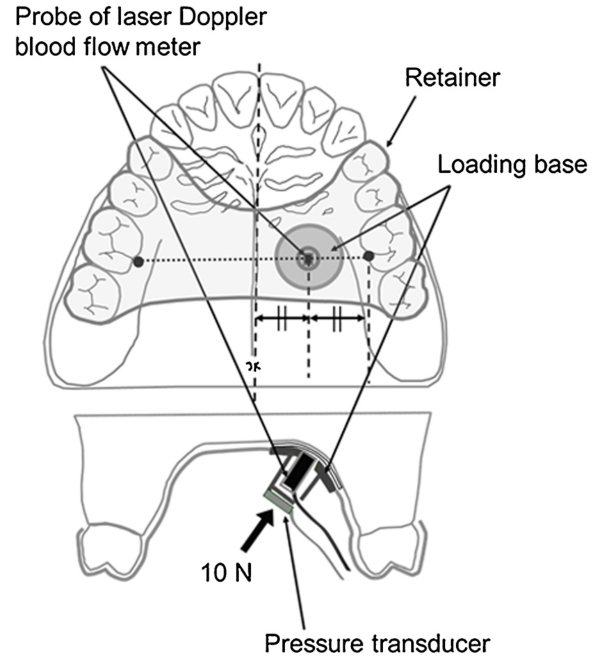

Fig. 1 – Position of retainer and loading base, and location of blood flow measuring device.

2.2. *Measurement of blood flow*

Subjects were required to refrain from eating and/or drinking (except water) within 6 h prior to commencement of the experiments [14]. For measurement, subjects were asked to assume the supine position in a quiet room with a temperature of 20–25 °C [15]. First, blood flow in denture-supporting mucosa without loading was recorded with the blood flowmeter. The loading area was changed if the wave patterns of the blood flow of the greater palatine artery was found. The blood flow was measured after observing more than 10 s of steady blood flow and was defined as the pre-loading blood