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Relationship between severity of periodontitis and masseter muscle activity during waking and sleeping hours

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ABSTRACT

Objective: This study was conducted to investigate whether the masseter muscle activity shows any specific pattern in relation to the severity of periodontitis.
Design: Sixteen subjects with no or mild periodontitis (NMP group) and 15 subjects with moderate or severe periodontitis (MSP group) were enrolled. Plasma IgG antibody titer was examined using *Porphyromonas gingivalis* as a bacterial antigen. Surface electromyography (EMG) of the masseter muscles was continuously recorded using an ambulatory surface EMG recording device while patients were awake and asleep. Masseter muscle activity was analyzed using intensities of 5%–10% maximal voluntary clenching (MVC), 10%–20% MVC, and > 20% MVC. Furthermore, EMG levels of 20% MVC were adopted as the threshold for analysis of phasic, tonic, and mixed EMG activities. The cumulative duration of masseter muscle activity and bruxism episodes was calculated as duration per hour.
Results: There was no significant difference in plasma IgG antibody titers against *P. gingivalis* between the NMP and MSP groups ($p = 0.423$). During waking hours, the duration of masseter muscle activity with an intensity of > 20% MVC was significantly longer in the MSP group than in the NMP group ($p = 0.037$). During sleeping hours, the duration of masseter muscle activity at all MVC intensities was significantly longer in the MSP group than in the NMP group (all $p < 0.05$). Additionally, the duration of phasic and mixed episodes was significantly longer in the MSP group than those in the NMP group while both awake and asleep (all $p < 0.05$).
Conclusions: The results of this study suggested that masseter muscle activity might be related to the severity of periodontitis.

1. Introduction

Although the relationship between masticatory muscle activity and periodontal disease has long been of interest, a clear relationship has not yet been revealed. Masticatory muscle activity is known to include functional and non-functional activities. Bruxism is a type of non-functional activities suggested by Lobbezoo et al. (2013). Kato et al. suggested that an increase in masticatory muscle activity during sleep would cause clinical complications of teeth and prostheses by generating occlusal overload (Kato, Yamaguchi, Okura, Abe, & Lavigne, 2013). Conversely, Manfredini et al. reported that there was no relationship between bruxism and periodontal disease (Manfredini, Ahlberg, Mura, & Lobbezoo, 2015). Therefore, the relationship between masticatory muscle activity and periodontal disease remains unclear.

One of the possible reasons why the relationship between masticatory muscle activity and periodontal disease has not been clarified is that the quantitative evaluation of muscle activities during sleep and awake has been difficult. Sleep bruxism is one of the masticatory muscle activities previously investigated in relation to periodontal diseases (Manfredini et al., 2015). Sleep bruxism has been evaluated using clinical assessments, questionnaires, polysomnography, or surface electromyography (EMG) (Shetty, Pitti, Satish Babu, Surendra Kumar, & Deepthi, 2010; Manfredini, Winocur, Guarda-Nardini, Paesani, & Lobbezoo, 2013; Jiménez-Silva, Peña-Durán, Tobar-Reyes, & Frugone-Zambra, 2017). However, Fujisawa et al. suggested that intraoral findings such as dental attrition and tongue and cheek impression are

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not necessarily associated with sleep bruxism and thus cannot be a reliable evidence of bruxism (Fujisawa et al., 2013). In addition, Yachida et al. reported that the diagnostic validity of self-reported measures of sleep bruxism was low to modest compared with the assessment using ambulatory surface EMG devices (Yachida et al., 2016). From the standpoint of evaluating actual muscle activity, surface EMG or polysomnography would be the most appropriate modality. In particular, a portable surface EMG would be useful for recording masticatory muscle activity while awake in daily life (Nishi, Basri, & Alam, 2016).

In previous studies that investigated bruxism in relation to periodontal disease, use of questionnaires, sometimes in combination with sleep surface EMG recording, to confirm the incidence of sleep bruxism has been achieved thus far (Hanamura et al., 1987; Martinez-Canut, Carrasquer, Magán, & Lorca, 1997; Ono, Suganuma, Shinya, Furuya, & Baba, 2008; Tokiwa et al., 2008). However, to our knowledge, no study recorded muscle activity throughout the whole day. In the study of masseter muscle activity, which was evaluated throughout the whole day in occlusal collapse patients using surface EMG recordings, Kawakami et al. reported that extensive occlusal collapse was significantly related to masseter muscle activity during awake (Kawakami, Kumazaki, Manda, Oki, & Minagi, 2014). Therefore, quantitative evaluation of masseter muscle activity may be an important modality to investigate the relationship between masseter muscle activity and periodontal conditions.

The aim of this study was to investigate whether the masseter muscle activity differed due to the severity of periodontitis by measuring a full day and night of masseter muscle activity using ambulatory surface EMG.

2. Materials and methods

2.1. Subjects

The present study was conducted from August 2014 to September 2015. Subjects were selected from outpatients receiving regular checkups at the Clinical Division of Preventive Dentistry, Okayama University Hospital. A total of 49 patients agreed to participate in the screening and were enrolled in the study. All subjects received an explanation of the nature and purpose of the study and provided written informed consent to participate. The study protocol was approved by the ethics committee of Okayama University Hospital (No. 2027).

The periodontal condition of each patient was evaluated according to the consensus definitions published by the joint Center for Disease Control/American Association of Periodontology working group (Eke, Page, Wei, Thornton-Evans, & Genco, 2012). Subjects were then classified by disease severity, i) no periodontitis or mild periodontitis or ii) moderate periodontitis or severe periodontitis, as previously described (Machida et al., 2014). Subjects were divided into two groups: no periodontitis or mild periodontitis (NMP) group and moderate or severe periodontitis (MSP) group. Inclusion criteria for the NMP group were: i) no periodontitis or mild periodontitis; ii) no history of tooth loss because of periodontitis; iii) existence of occlusal contact on bilateral premolar and/or molar with opposing teeth; iv) no acute inflammation in periodontal tissues; v) bleeding on probing in $< 20\%$ of probed sites; and vi) no occlusal pain in remaining teeth. Inclusion criteria for the MSP group were: i) moderate or severe periodontitis; ii) existence of occlusal contact on bilateral premolar and/or molar with opposing teeth; iii) no acute inflammation in periodontal tissues; iv) bleeding on probing in $< 20\%$ of probed sites; and v) no occlusal pain in remaining teeth. The NMP group consisted of 16 patients (3 males and 13 females; mean age, 64.5 ± 11.4 years), and the MSP group consisted of 15 patients (6 males and 9 females; mean age, 66.7 ± 6.5 years). 31 of the 49 subjects met the inclusion criteria and 18 subjects did not meet them.

Exclusion criteria were as follows: i) use of benzodiazepine and/or muscle relaxant; ii) alcohol and/or narcotic drug abuse; iii) sleep disorders; iv) temporomandibular disorders according to the Research Diagnostic Criteria for Temporomandibular Disorders classifications (Dworkin & LeResche, 1992); or v) pain in any part of the body.

2.2. IgG antibody titer against Porphyromonas gingivalis

To investigate the infection status of subjects with periodontal pathogens, plasma IgG antibody titer was examined using *Porphyromonas gingivalis* as a bacterial antigen in accordance with the study by Kudo et al. (Kudo et al., 2012). A 50-μL quantity of whole blood was sampled from the tip of the middle finger of each subject and processed using a dedicated plasma IgG titration ELISA kit for *P. gingivalis* (Demecal; Leisure Inc., Tokyo, Japan).

2.3. Surface EMG data recording

Surface EMG activity of the left masseter muscles was recorded as previously described (Kumazaki et al., 2014). Since the electrodes were connected from the recording hardware with a cable, the masseter activity was recorded only on the left side in order to alleviate troubles such as detachment of the cable. Measurements were carried out by one investigator (SeK). Surface EMG measurement was scheduled to start between 9:00 a.m. and 12:00 p.m. according to each subject's preference. Before the electrode was fixed, the skin was vigorously rubbed with a pad soaked in 70% ethyl alcohol. Surface EMG of the left masseter muscle was recorded using differential surface electrodes composed of three disposable silver/silver chloride surface electrodes (6 × 15 mm, Vitrode F-150S; Nihon Kohden Corp., Tokyo, Japan) with a center-to-center distance of 15 mm. The electrodes and cables were secured to the buccal skin with thin biocompatible adhesive tape (Cathereep FS 1010; Nichiban Co. Ltd., Tokyo, Japan). The recording hardware for surface EMG consisted of an analogue signal processing and differential amplification integrated hybrid circuit (NB-6201HS; Nabtesco Co., Kobe, Japan), which included a 10 Hz high-pass filter and 1000 Hz low-pass filter, and a two-channel digital recorder(ICR-PS004 M; Sanyo Electric Co., Ltd., Osaka, Japan). To distinguish surface EMG activity during speech, a voice-operated trigger switch was used with a condenser microphone attached to the neck skin adjacent to the larynx. The voice-operated trigger signal was recorded on the second channel of a two-channel digital recorder. After wearing the ambulatory surface EMG recording hardware, subjects were instructed to perform maximal voluntary clenching (MVC) three times for 2 s at intervals of 2 s. The highest signal among these three clenching trials was regarded as 100% MVC. After completion of all these procedures, subjects left the hospital and went about their daily lives. Subjects were instructed to remove the voice-operated trigger microphone just before sleep. Surface EMG was recorded throughout the day and was scheduled to continue recording until the subject woke up the next morning. Subjects with dentures were instructed to use them as usual. Subjects were instructed to keep a diary describing their daily activities, including eating meals, reading books, and other activities.

2.4. Data analysis

Collected surface EMG data were processed offline, filtered with a 500 Hz low-pass filter and a 60 Hz notch filter, and then rectified with root mean square conversion with an integration time of 10 ms. Fig. 1 shows raw data example of surface EMG. EMG signals accompanied by positive voice-operated trigger signals were regarded as masseter muscle activity with utterance. Since this study evaluated the periodontal condition, masseter muscle activity with utterance, which is generally performed without tooth contact, was excluded from subsequent analysis. Masseter muscle activity during mastication was analyzed separately from other masseter muscle activity because mastication was regarded as a routine masseter muscle activity performed in daily life and was easily identifiable. Surface EMG activity during