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Objective assessment of actual chewing side by measurement of bilateral masseter muscle electromyography

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ABSTRACT

Objective: The aim of this study was to examine the validity of objective assessment of actual chewing side by measurement of electromyographic (EMG) activity of the bilateral masseter muscles upon chewing test foods.
Design: The sample consisted of 19 healthy, dentate individuals. The subjects were asked to chew three types of test foods (peanuts, beef jerky, and chewing gum) for 10 strokes on the right side and then on the left side, and instructed to perform maximum voluntary clenching for 3 s, three times. EMG activity from the bilateral masseter muscles was recorded. The data were collected in three different days. The root mean square EMG amplitude obtained from the maximum clenching task was used as the maximum voluntary contraction (MVC). Then, the level of amplitude against the MVC (%MVC) was calculated for the right and left sides on each stroke. The side with the larger %MVC value was judged as the chewing side, and the concordance rates (CRs) for the instructed chewing side (ICS) and the judged chewing side (JCS) were calculated. Intraclass correlation coefficients (ICCs) of the CRs were calculated to evaluate the reproducibility of the method.
Results: High CRs between the ICS and JCS for each test food were recognized. There were significant ICCs for beef jerky ($R = 0.761$, $P < 0.001$) and chewing gum ($R = 0.785$, $P < 0.001$).
Conclusions: The results suggested that the measurement of EMG activity from the bilateral masseter muscles may be a useful method for the objective determination of the actual chewing side during mastication.

1. Introduction

Mastication is an almost automatic and subconscious activity of daily living. Several previous studies have shown that many healthy individuals prefer to chew more on either the right or left side of the mouth, referred to as the “preferred chewing side” (Ratnasari et al., 2011; Wictorin, Hedegard, & Lundberg, 1968; Wilding & Lewin, 1991a; Zamanlu et al., 2012). In this study, chewing predominantly on one side is defined as mastication predominance. Mastication predominance is thought to be related to temporomandibular disorders (TMD), temporomandibular joint disc displacement and asymmetrical loss of teeth (Diernberger, Bernhardt, Schwahn, & Kordass, 2008; Farias Gomes, Custodio, Moura Jufer, Der Ber Cury, & Rodrigues Garcia, 2010; Ferreira, Machado, Borges, Silva, Sforza, & Felicio, 2014; Ratnasari et al., 2011; Santana, Lopez, Mora, Otero, & Santana, 2013). It has been reported that excessive mastication predominance could cause laterality in stomatognathic function, including jaw movement pattern, bite force and mastication efficiency (Bates, Stafford, & Harrison, 1975; Mohl, Zarb, Carlsson, & Rugh, 1988; Wilding, Adams, & Lewin, 1992). Hence, it is generally believed that chewing equally on both sides is recommended to prevent these conditions, despite a lack of reliable scientific research on this issue.

Many studies have been conducted on patients' preferred chewing side. Questionnaires have often been used to determine the preferred chewing side subjectively (Diernberger et al., 2008; Nissan, Gross, Shifman, Tzadok, & Assif, 2004). Although this method can be easily applied both in clinical and research situations, its validity is questionable. Some studies have also evaluated the preferred chewing side objectively by investigating the first chewing

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cycle (Kazazoglu, Heath, & Muller, 1994; Nissan et al., 2004), electromyographic (EMG) activity (Devlin, Wastell, Duxbury, & Grant, 1987; Zamanlu et al., 2012) and jaw movement patterns (Stohler, 1986; Wilding & Lewin, 1991b). These studies reported that it was possible to determine whether the right or left sides were preferred for mastication. However, the mastication predominance, i.e., how often chewing was actually performed on the side determined using these methods, was not evaluated. Several studies have evaluated mastication predominance by the number of right- and left-sided closing strokes observed while recording jaw movement in the lower incisal region in healthy, dentate subjects (Mizumori, Tsubakimoto, Iwasaki, & Nakamura, 2003; Wilding & Lewin, 1991a). Devices used to measure jaw movement, such as the kinesiograph, are superior in judging the actual chewing side accurately. However, they are too large for practical use in the clinical setting. Furthermore, the sensor which is placed in the mouth to measure jaw movements may also have some influence on chewing function. Therefore, a more accurate and practical method of assessing actual chewing side must be developed.

Recently, some portable devices have been developed to facilitate chair-side bioinstrumentation. For example, the portable EMG recording device facilitates accurate measurement of EMG activity.

The aim of this study was to examine the validity of the objective assessment of actual chewing side by measurement of bilateral masseter muscle EMG activity upon chewing test foods.

2. Materials and methods

2.1. Subjects

In the present study, 19 healthy, dentate volunteers (11 males and 8 females; mean age: 31.3 years; age range: 24–44 years) were recruited from the staff at Kyushu University. Inclusion criteria for the healthy, dentate group were individuals over 20 years old, having 28 natural teeth in addition to the third molars. The following individuals were excluded from the study: those receiving ongoing dental therapy, including orthodontic treatment; those exhibiting systemic illness or dental disease with possible effects on mastication; those with jaw dysfunction and/or pain such as temporomandibular disorders; and those with compromised mental capacity due to dementia or other psychiatric diseases. The occlusal status of subjects was as follows: two subjects (subject 7 and 8) had crossbite, one subject (subject 8) had balancing side contacts, one subject (subject 19) had orthodontic treatment, and no one had prostheses. Other occlusal status (lateral movement guidance, overbite, overjet, dental class) and preferred chewing side is shown in Table 1. The lateral movement guidance was assessed intraorally using occlusal registration strips.

Each subject provided informed consent prior to commencement of the experiments.

Table 1
Occlusal status and preferred chewing side of subjects.

Subject no.	Lateral movement guidance	Overbite (mm)	Overjet (mm)	Dental class	Preferred chewing side (questionnaire)
1	R: 11,12,13,41,42,43 L: 21,22,23,31,32,33	3.5	1.0	R: II L: I	R
2	R: 11,12,14,41,42,42 L: 22,23,24,31,32,33,34	4.1	3.4	R: I L: I	L
3	R: 13,14,43,44 L: 23,24,33,34	3.0	1.5	R: III L: III	R
4	R: 12,13,42,43 L: 23,24,25,26,27,33,34,35,36,37	2.4	1.0	R: II L: II	L
5	R: 14,15,16,17,44,45,46,47 L: 23,24,25,33,34,35	0.8	1.8	R: I L: I	R
6	R: 13,14,15,16,43,44,45,46 L: 23,24,25,26,33,34,35,36	-0.5	1.0	R: I L: I	L
7	R: 12,13,14,15 L: 23,24,25,33,34,35	2.5	2.9	R: I L: I	R
8	R: 11,12,13,14,41,42,43,44 L: 21,22,23,31,32,33	5.2	0.5	R: I L: I	R
9	R: 12,13,14,15,22,23,24,25 L: 22,23,24,25,32,33,34,35,36	1.2	0.5	R: III L: III	R
10	R: 13,14,43,44,45 L: 23,24,33,34	0.5	0.5	R: III L: III	–
11	R: 13,43 L: L23,33	5.0	2.2	R: III L: II	L
12	R: 13,14,43,44 L: 23,33	6.2	3.1	R: I L: I	L
13	R: 11,12,14,15,16,17,41,42,43,44,45,46,47 L: 21,22,23,24,25,26,27,31,32,33,34,35,36,37	0	1.0	R: III L: I	–
14	R: 13,14,43,44 L: 23,33	2.5	4.0	R: II L: II	–
15	R: 13,43 L: 23,24,33,34	3.0	2.0	R: II L: I	L
16	R: 11,13,14,41,43,44 L: 21,22,23,24,25,26,31,32,33,34,35,36	6.3	2.8	R: I L: I	–
17	R: 11,14,15,16,41,44,45,46 L: 22,24,25,26,32,34,35,36	1.0	1.5	R: I L: I	L
18	R: 13,14,15,43,44,45 L: 23,24,25,33,34,35	1.8	2.5	R: I L: I	R
19	R: 13,14 L: 23,33	2.0	2.0	R: I L: I	R

Preferred chewing side (questionnaire): preferred chewing side determined by the questionnaire. R: right; L: left.