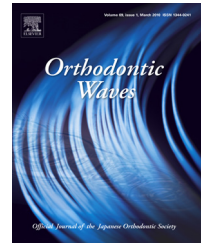


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Original article

Evaluation of the laterality of the tissue oxygen saturation of masticatory muscles in subjects with facial asymmetry

Katsuhiko Suzuki^{a,*}, Satoshi Kokai^a, Shunsuke Uesugi^a,
Akira Nishiyama^b, Takashi Ono^a

^a Orthodontic Science, Graduate School, Tokyo Medical and Dental University, Japan

^b Orofacial Pain Management, Graduate School, Tokyo Medical and Dental University, Japan

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ABSTRACT

Purpose: In subjects with facial asymmetry (FA), both morphological and functional lateralities in the masticatory muscles have been reported in literature. However, most studies evaluated masticatory muscle activity by electromyography. No report has analyzed tissue oxygen saturation (StO₂) in subjects with FA. In this study, we aimed to investigate the hemodynamic laterality by measuring the bilateral masticatory muscle StO₂ in subjects with FA.

Materials and methods: The subjects were divided into three groups: Group A, Class III skeletal relationship with mandibular deviation of ≥ 3.0 mm; Group B, Class III skeletal relationship with mandibular deviation of < 3.0 mm; and Group C, normal skeletal relationship and occlusion. We used near-infrared spectroscopy to measure the bilateral masticatory muscle StO₂ at rest, immediately after maximum clenching for 10s, and 30s after maximum clenching. We calculated the reduction rate of StO₂ after maximum clenching and its recovery rate after 30s from the end of clenching, and statistically compared both sides within each group.

Results: With regards to the reduction and recovery rates of StO₂, significant difference was not found between sides in Groups B and C. However, a significant difference was observed in Group A; the reduction rate was significantly larger, and the recovery rate was significantly smaller in the side of mandibular deviation.

Conclusions: Hemodynamic laterality was found in the masticatory muscles between the deviated and non-deviated sides of the mandible in subjects with FA.

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* Corresponding author at: Department of Orthodontic Science, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8549, Japan. Fax: +81 3 5803 5528.

E-mail address: k.suzuki0513@gmail.com (K. Suzuki).

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1. Introduction

Orthognathic surgery is an effective treatment option to achieve ideal occlusion and improve skeletal morphology and facial appearance in subjects with facial deformity and disharmony between the maxilla and mandible. Esthetic demands of patients include improvements in the horizontal and vertical dimensions of the maxilla and the mandible that alter the facial profile, as well as the facial asymmetry (FA) in the frontal aspect; this is one of the important treatment goals for orthognathic surgery. Therefore, evaluation of FA is an important factor for a successful orthognathic/orthodontic treatment. However, estimating FA accurately before treatment is difficult because it requires bilateral evaluation and agreement by the patient and the operator. Numerous morphologic studies have evaluated the skeletal and soft tissue characteristics of patients with FA in the lateral and frontal aspects for diagnosis and treatment planning [1,2].

Moreover, many previous studies indicated that subjects with FA not only have morphologic problems but also functional disorders in the oral and facial areas, such as imbalanced occlusal force and temporomandibular disorders (TMDs) [3,4]. Occlusal force and masticatory muscle activity of the deviated side (DS) of the mandible are significantly greater than those of the non-deviated side (NDS) of the mandible. In addition, the prevalence of TMDs is higher in patients with FA and is more frequent in DS [3,4]. In literature, electromyography has been used to evaluate the laterality of masticatory muscle activity to elucidate the mechanism of functional lateralities [5,6]. On the other hand, previous studies reported that patients with TMDs may have disorder in fatigue and recovery of masticatory muscle [7]. Blood flow and tissue oxygen saturation (StO₂) in masticatory muscle tissue may be greatly related to TMDs [8]. Therefore, evaluation of the masticatory muscle StO₂ may be an effective method to clarify the functional complications of FA. However, the laterality of blood flow in the DS and NDS has not been measured and compared.

In the present study, we investigated the relationships between functional asymmetry and hemodynamic laterality in subjects with FA by using near-infrared spectroscopy (NIRS) [9]. NIRS can quantify the muscle blood flow and StO₂ easily and non-invasively.

2. Materials and methods

2.1. Subjects

The study design and ethical considerations were approved by the ethical committee of Tokyo Medical and Dental University (approval number: D2015-512) in Japan.

We randomly selected 14 subjects with both mandibular protrusion and FA from the pooled patients who visited the Orthodontic Department of Tokyo Medical and Dental University Dental Hospital. The patients were divided into 2 groups according to the amount of mandibular lateral deviation, defined as a Menton deviation from the cranial midline in the posteroanterior (PA) cephalometric radiograph (Fig. 1) [10].

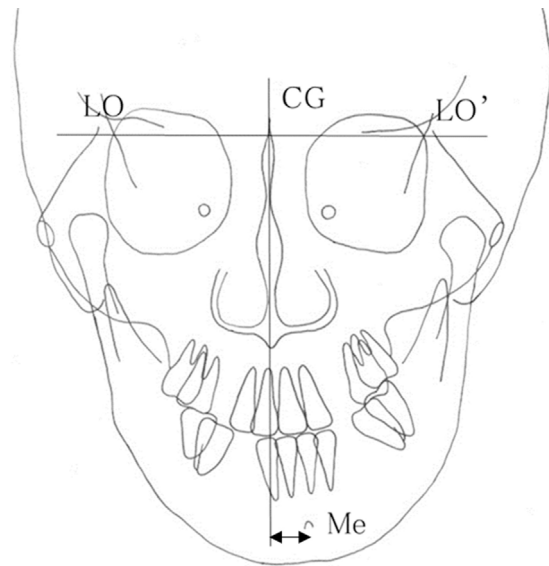


Fig. 1 – Method of midline evaluation. A line passing through the CG (Crista Galli) and vertical to the LO-LO' line (reference line) is defined as the midline, and the distance from Menton to the midline is taken as the amount of mandibular deviation.

Group A comprised 7 subjects [6 men and 1 woman, aged 22.5 ± 5.4 (mean \pm SD) years] with Menton deviated equal to or more than 3.0mm. Group B comprised 7 subjects [5 men and 2 women, aged 25.9 ± 6.3 (mean \pm SD) years] with Menton deviated less than 3.0mm.

We also selected 7 subjects [5 men and 2 women, aged 25.9 ± 6.3 (mean \pm SD) years] with normal occlusions from the staff of our department as the control group (Group C). All subjects met the following criteria: (1) over 18 years old, (2) no previous orthodontic treatment, (3) no congenital missing teeth, and (4) no congenital anomaly. We examined TMDs in subjects of Groups A and B before recordings, and found that 3 subjects in Group A exhibited the masseter muscle pain. However, the severity was mild and there was no relationship between the side of mandibular deviation and masticatory muscle pain.

We performed lateral cephalometric analysis and evaluated the lateral Menton deviation using the PA cephalometric radiographs. We also compared the parameters of cephalometric measurements between Groups A and B. No significant differences in lateral cephalometric parameters were found, but the amount of Menton deviation was significantly larger in Group A than in Group B ($p < 0.05$; t-test) (Table 1).

2.2. Recordings

The StO₂ of the bilateral masseter muscles and anterior temporalis muscles was measured using NIRS (OMEGAWAVE Inc., Tokyo, Japan) with a probe and a detector connected to an oxygen monitor (BOM-L1TRW; OMEGAWAVE Inc., Tokyo, Japan). The output from the oxygen monitor was recorded and analyzed using a laptop computer with software (Lab-Chart; ADInstruments, Australia) via an AD converter (Power-Lab; ADInstruments, Australia) (Fig. 2).

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