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Brain Activity in Class II Div. 1 Malocclusion Subjects after Setting Twin-block Appliance

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The purpose of the study was to clarify the effects of gum-chewing on the primary motor area (PMA) when advancing the mandible with a twin block appliance (TBA). Twenty male adults were divided into the Class I (normal malocclusion, n=10) and Class II (Class II div. 1 malocclusion undergoing mandibular retrusion, n=10) groups. Brain activity, monitored with an Near Infra-Red Spectoroscopy (NIRS), was significantly elevated in the Class I group with a TBA at 0 mm of advancement, while it was also significantly greater in the Class II group without a TBA. Furthermore, when fitted with a TBA with 4-6 mm of advancement, brain activity in the Class II group declined and became near that in the Class I group. These findings indicate the significance of improving the jaw relationship to normal in patients undergoing mandibular retrusion using a TBA from the aspect of brain activity involving the stomatognathic motor area.

Key words : Class II div. 1, brain activity, twin block appliance, mandibular advancement, NIRS

Introduction

It is well known that Class II div. 1 malocclusion is related to mouth breathing due to an upper airway obstruction[1)] or upper airway stenosis[2)], even without the presence of bradyauxesis. Furthermore, it has also been revealed that an increase in nasal resistance that causes mouth breathing is closely associated with overjet increase, apertognathia, and maxillary crowding[3)]. Class II div. 1 malocclusion is frequently caused by bradyauxesis of the lower jaw[4~10)], while it is also considered that sleep apnea syndrome is often caused by an upper airway lesion and closely linked with mandibular retrusion. Accordingly, it is thought that Class II malocclusion patients have inefficient oxygen intake due to mandibular retrusion, similar to sleep apnea patients.

For the treatment of Class II div. 1 malocclusion, a jaw function corrector to facilitate forward growth of the mandible while raising the bite has been shown to attain favorable therapeutic effects[8~11)]. A twin block appliance (TBA)[11)], a type of jaw function corrector, enables masticatory movement while protruding the mandible, allowing occlusal force to be conveyed to the upper and lower tooth rows, which facilitates growth of the articular process. A TBA exerts stress on the tissues surrounding the mouth and three months are generally required before the fit becomes comfortable[11)]. Intraoral appliances used by patients with sleep apnea syndrome have greater effects as the mandible is advanced[12)], and drastically improve snoring and apnea symptoms during sleep[13,14)].

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Cerebral blood flow is associated with brain activity, and brain activities during masticatory movement[15,16] before and after improvement of occlusal function[17] as well as at the time of mandibular advancement[14] have been studied extensively using MRI and optical topography examinations. However, no known study has clarified brain activity in patients with mandibular retrusion during gum-chewing while the mandible was advanced to a protruding position. In the present study, we investigated the effects of mandible advancement with a TBA on the motor area in patients with Class Ⅱ div. 1 malocclusion.

Materials and Methods

1. Subjects

Twenty male students (24.1±3.0 years old) of our university who provided informed consent after learning the purpose and significance of the study were used as subjects. The subjects were divided into two groups ; those who had Class Ⅱ div. 1 malocclusion with mandibular retrusion shown in an examination of facial appearance (Class Ⅱ group, 24.0±4.2 years old, n=10), and those who demonstrated nasal breathing and normal occlusion with refined facial features (Class Ⅰ group, 24.3±1.1 years old, n=10). There was no statistically significant difference for mean age between the groups. In contrast, a significant difference was observed for mean overjet, which was +11.1 mm in the Class Ⅱ group and +1.9 mm in the Class Ⅰ group ($p<0.01$). Furthermore, 60% of the subjects in the Class Ⅱ group snored regularly.

2. Preparation of twin block appliance (TBA)

The construction bite was registered by setting the vertical dimension between the central incisors of the upper and lower jaws at 2 mm, and the longitudinal dimension at 0 mm using a Pro-Jet Bite Jigs 2-mm kit (Great Lakes, N. Y., USA). In this study, the occlusion was raised by about 3-5 mm at the molars[11]. Oral models of the upper and lower jaws were attached to an articulator (FKO Split post-fix Zetor, Dentauram, Ispringen, Germany) via a projet bite gauge. A stainless-steel screw was incorporated into the block of the appliance for the upper jaw to make it parallel with the occlusal plane and construct a mechanism for precisely adjusting the amount of mandibular advancement[18].

3. Measurement of cerebral blood flow

For measuring cerebral blood flow, optical topographic equipment (ETG-100, Hitachi Medico, Tokyo Japan) was used. In the present study, for measuring cerebral blood flow in the primary motor area (PMA), which is involved in stomatognathic function, an optical fiber cap with 12 channels on each side (illumination-detection distance 30 mm, total 24 channels) was attached to the skull from the vertex to the temporal region. To determine brain function with near-infrared light in accordance with International Procedures 10-20, the region equivalent to the primary sensorimotor area involved in stomatognathic function associated with mastication and swallowing was identified, to which an optical fiber cap was attached by matching it to the central fissure. The room temperature was set at 25±1℃. The experimental plan was approved by the ethics committee of our university.

4. Task

During the measurements, the subjects were instructed to be seated with their posture at rest while a probe cap was attached to the skull. Gum to be chewed was pre-softened. In the Class Ⅰ group, blood flow was determined with and without a TBA, while in the Class Ⅱ group, that determination was made under 5 different conditions ; without a TBA, and with a TBA advanced by 0, 2, 4, and 6 mm (Fig. 1). For setting the amount of construction bite, a

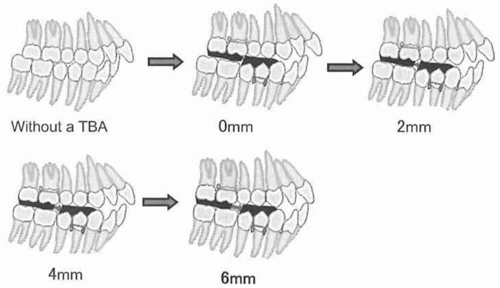

Fig 1. Setting mandibular advancement.
A screw used for mandibular advancement was incorporated in the upper molar block of the twin block appliances. Mandibular advancement of 0, 2, 4, and 6 mm was adjusted by vertically elevating the mandible between the central incisors of the upper and lower jaws.

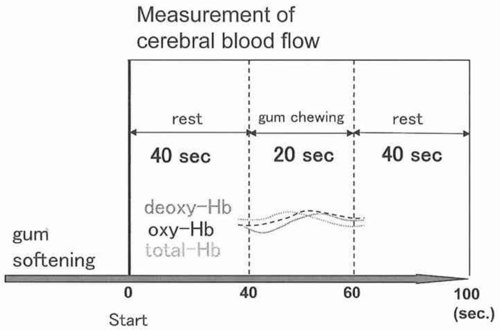

Fig 2. Task and measurements.
Cerebral blood flow was measured as follows. After keeping the mandible at rest for 40 seconds from the start of measuring, a gum-chewing task was performed for 20 seconds, after which the mandible was kept at rest for 40 seconds. The procedure was repeated twice, after which the measurements were completed.

digimatic caliper (Mitutoyo, Kanagawa, Japan) with a minimum indication of 0.01 mm and instrumental error of ±0.02 mm was used. After keeping the lower jaw at rest for 40 seconds from the start of the measurement, the gum-chewing task was performed for 20 seconds. Then, after another 40-second rest period, gum-chewing was repeated for 20 seconds and the measurement was completed after a final rest for 40 seconds (Fig. 2). During the task, the subjects were instructed to chew freely.

5. Data analysis

There is an approximately 6-second time lag until changes in neural activity are reflected as changes in cerebral blood flow[19]. Accordingly, the gradient of the primary line obtained from the linearized curve of the total-Hb waveform for the 10-second period from 6 seconds after the start of gum-chewing under each condition was regarded as cerebral blood flow (Fig. 3). Blood flow was measured at 12 points on each side, for a total of 24. For the gradient of the total-Hb waveform, a positive sign was regarded as an increase in cerebral blood flow, while a negative sign was regarded as a decrease.

For statistical analysis, the results obtained

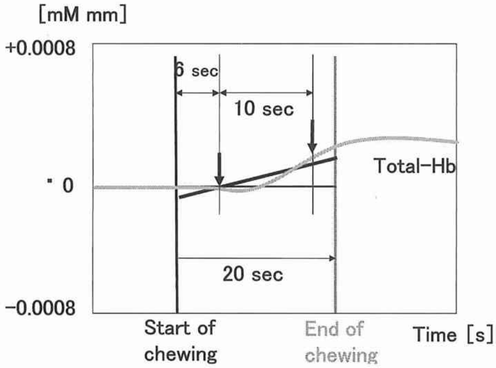

Fig. 3 Analysis of the total Hb waveform.
After 6 seconds of gum-chewing, a gradient of the line was obtained on the basis of a linearized curve for 10 seconds.

from each of the 24 channels for the Class I group without a TBA and with a TBA at 0 mm of advancement were compared using a Wilcoxon t-test. Results for the Class I and Class II groups with and without a TBA were examined by a Mann-Whitney U test. In the Class II group, results obtained for the subjects without a TBA and with a TBA set at 0, 2, 4, and 6 mm of advancement were studied using a Wilcoxon t-test with Bonferroni correction for multiple comparisons.

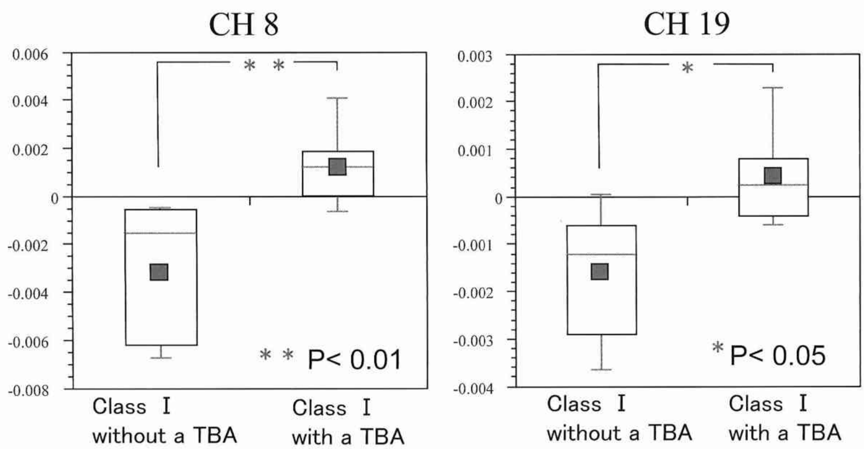

Fig 4. Brain activity during gum-chewing in Class I group.

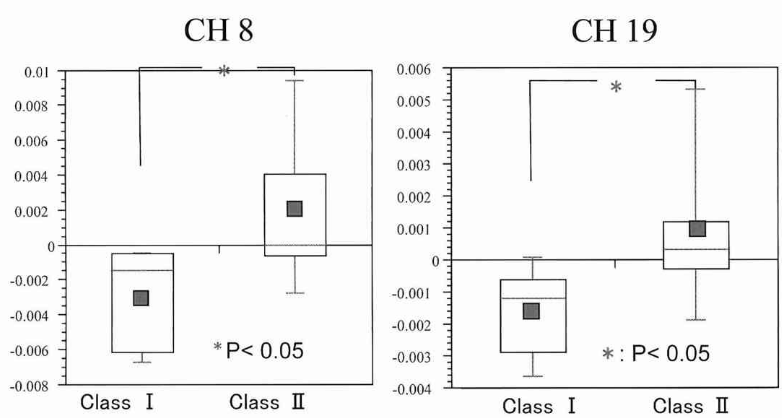

Fig 5. Comparison between Class I and Class II during gum-chewing without a TBA.

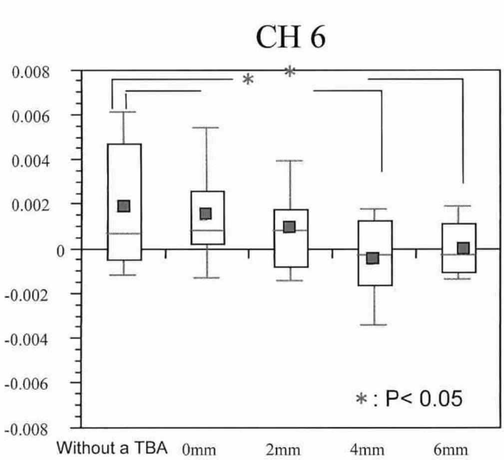

Fig 6. Multiple comparisons in Class II group.

Results

Blood flow in the Class I group with a TBA was significantly elevated at Ch. 8 (median : 1.1 x 10^{-3}, interquartile deviation 1.8 x 10^{-3}) on the left hemisphere and Ch. 19 (median : 0.7 x 10^{-3}, interquartile deviation 2.0 x 10^{-3}) on the right hemisphere ($p<0.05$) (Fig. 4). The Class II group without a TBA showed significantly higher levels of blood flow in the motor regions related to oral function, which were Ch. 8 of the left hemisphere (median 1.4 x 10^{-3}, interquartile deviation 9.3 x 10^{-3}) and Ch. 19 of the right hemisphere (median -7.5 x 10^{-3}, interquartile deviation 3.5 x 10^{-3})

($p<0.05$) (Fig. 5). Furthermore, comparisons of the groups with a TBA did not show any significant differences between the respective channels.

Blood flow in the Class II group was examined by multiple comparisons among without a TBA and the 5 conditions of 0-6 mm of advancement, with the results shown in Figure 6. At Ch. 6, which represented oral function of the primary motor area, blood flow declined significantly with advancements of 4 mm (median 0.7×10^{-3}, interquartile deviation 3.6×10^{-3}) and 6 mm (median -0.2×10^{-3}, interquartile deviation 2.0×10^{-3}). In contrast, no significant differences were observed between the channels representing the oral region of the primary motor area and central fissure. There were also no significant differences observed among any of the channels that represented the oral region of the primary motor area with mandibular advancements of 0 and 2 mm (Fig. 6).

Discussion

Cerebral blood flow during gum-chewing in subjects without a TBA was compared between the Class I and II groups. In the Class II group, blood flow was significantly elevated at Ch. 8 of the left hemisphere and Ch. 19 of the right hemisphere, which represent the motor region of oral function. Hill *et al*[20]. found that flow in the middle cerebral artery was greater in children with moderate sleep apnea syndrome. Class II malocclusion patients frequently have sleep apnea syndrome[21], as the rhinopharyngeal cavity in those patients is narrow, even though they may demonstrate a vertical growth pattern[22]. In the present study, the Class II group had a significantly greater amount of overjet (mean +11.1 mm) as compared to the Class I group (+1.9 mm) and we speculated that they demonstrated the characteristics of mandibular retrusion due to a marked skeletal Class II morphology. Accordingly, brain activity in the primary motor area of the Class II group may have become elevated to compensate for the loss of oxygen quantity in order to respond to the elevation of airway resistance caused by stenosis in the pharyngeal cavity, similar to patients with sleep apnea syndrome.

There was no significant difference in brain activity between the Class I and Class II groups when the TBA was set at 0 mm of advancement. Moreover, no statistically significant difference was observed between the Class II group without a TBA and that with a TBA at 0 mm of advancement. These results suggest that brain activity was enhanced by gum-chewing in the Class I group with a TBA. Nakamura *et al*[18]. observed no significant difference in brain activity in healthy subjects between before and after performance of a tapping task. In the present study, brain activity was enhanced when a TBA was attached, which may have been because of differences between tapping and gum-chewing.

Maeda and Fukumi[23] reported that 5 mm of occlusal elevation was effective to improve brain activity in healthy subjects. In the present study, occlusion in the subjects was elevated by about 3-5mm, as the height of the anterior teeth was set at 2 mm when preparing the TBA. Accordingly, it was considered that elevation of brain activity in the Class I group might have been the result of occlusal elevation by TBA attachment.

An oral appliance that advances the mandible has been used in treatment for sleep apnea syndrome[24,25] and also employed to enlarge the pharyngeal airway for easier breathing[26]. Kairaitis *et al.*[27] showed that mandibular advancement in rabbits reduced pressure in the airway and reduced air resistance in the upper airway, even when the mouth was closed. In addition, Hashimoto *et al.*[14] reported MRI findings showing that respiratory stress was reduced and brain activity stress alleviated following mandibular advancement in 67% of their healthy subjects.

In the present study, mandibular advancement of 4 and 6 mm, which approximated a condition of about 50% of the mean overjet (+11 mm), caused brain activity at Ch. 6 to decline in the Class II group. Since those subjects demonstrated mandibular retrusion for anatomical reasons, it was considered that they had a skeletal morphology similar to that of patients with sleep apnea syndrome. Accordingly, we speculated that a reduction in brain activity in Class II malocclusion patients can be induced by 4 of 6 mm of mandibular advancement, which enlarges the airway and alleviates stress on brain activity for motor control around the airway, as also seen in patients with sleep apnea syndrome.

Conclusion

Brain activity in the primary motor area during gum-chewing showed high levels in Class II div. 1 patients when fitted with a TBA. Those levels declined to nearly those of Class I patients with normal occlusion when a TBA was attached and the mandible was advanced by a large amount. These results indicate the significance of improving the jaw relationship to normal by use of a TBA in patients undergoing mandibular retrusion from the aspect of brain activity involving the stomatognathic motor area.

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