Abstract

Articulation disorders are divided into three types. The first is dysglossia caused by congenital or acquired morphological abnormalities of articulatory organs. The second is dysarthria caused by nervous and muscular lesions. The third is dyslalia in which there is no abnormality in the morphological form and function of articulatory organs. According to one report, there are about 300,000 Dysarthria patients in Japan. According to the Guidelines for the Treatment of Stroke 2015, the recommendation grade of functional training for Dysarthria is C1(You may consider conducting training. But it doesn't have enough scientific evidence). The level of evidence of rehabilitation for Dysarthria is still not enough. Therefore, scientific research on Dysarthria is needed.

In Dysarthria patients, abnormal movements such as a “pull-in” pattern and a “centering” pattern are observed when producing voiceless velar plosive/ k /. It is a clinically important problem to evaluate the mechanism of such abnormal movement during articulation. However, it is difficult to distinguish whether the articulatory movement abnormality is caused by (1) a movement abnormality due to a neurological disease or (2) a movement to supplement the movement abnormality. In the measurement experiment, to get a clue to separate factor(1) and factor (2), we examined whether the pattern of "pulling in" and "centering" observed in Dysarthria patients was observed or not in the compensatory movement of normal subjects without the factor (1). In the simulation experiment, the mechanism of the compensatory movement was examined using a simulation based on a 3D tongue model.

The subjects of the measurement experiment were 7 normal Japanese speakers (1 female and 6 male). Their articulation movement was measured by EMA (Electromagnetic articulpgragh). EMA is a device that attaches a sensor to the articulator and measures its position magnetically. We use 7 sensors in the experiment. One sensor was placed at the Nasion (reference sensor), one on the lower gum, three on the mid sagittal plane of the tongue, one on the left side of the tongue and one on the right side. The speech material was / aka // aki // aku // ake // ako /. There are three utterance conditions: (a) normal utterance condition for uttering as usual, (b) utterance condition while biting the tongue depressor, and (c) utterance condition with maximum jaw-opening position. (b) and (c) were set to extend the range of elevation of the posterior tongue needed for articulation and to induce compensatory movement. The extension of the distance between the lower gums and the tongue tip was used as an

index of “pull-in”, and the reduction of the distance between the left and right sensors was used as an index of “centering”.

As a result, when compared with the condition (a), in the both condition (b) and (c), the distance between the lower gum and the tongue tip was significantly increased in 6 out of 7 subjects. The left-right distance was significantly reduced in two of the seven subjects. (Including duplicates). “Pull-in” was observed in many subjects. In comparison, "centering" was observed in a smaller number of subjects. However, since the total number of subjects is small, the number of subjects in which “centering” is observed is not a negligible number. Contrary to the prediction, a significant reduction in the distance between the left and right sensors was observed in 5 out of 7 subjects. We thought that "pull-in" was caused by the compensatory action of the posterior tongue elevation due to increased activity of the styloglossus(SG). We thought that “centering” was caused by the compensatory action of the posterior tongue elevation due to increased transverse (T) activity. The increase in the width between the left and right was considered to be a secondary effect of the increased activity of SG. There were individual differences between subjects in the results of the experiment. Although our results did not provide enough evidence, it was suggested that individual differences between subjects may be related to the relative size of the tongue relative to the oropharynx.

In the simulation experiment, a simulation was performed using a three-dimensional tongue model created by Dang and his colleagues to examine the mechanism described above. When the mandible of the normal / k / articulatory movement model was lowered, the elevation range of the posterior tongue surface was lowered by 2.53 mm. This was called the “jaw-opening model”. To compensate for the lack of elevation, a "pull-in model" was created in which the activities of the SG were increased until the posterior tongue was at the same height. Similarly, to compensate for the lack of elevation, a "centering model" was created in which T's activity was increased until the posterior tongue was at the same height. Then, the displacement between the “opening model” and the “pull-in model” was obtained. And then, comparison was made with the average value of displacement between the normal condition and the opening condition of the subject representing the “pull-in” pattern. For comparison, the average value of the mandible gum-tongue tip distance and the width of the right and left tongues of / aka / ~ / ako / was used. Similarly, the displacement between the “jaw-openig model” and the “centering model” was compared with that of a subject representing the “centering” pattern.

The displacement of the mandibular gum-tongue tip distance between the “jaw-opening model” and the “pull-in model” was 4.97 mm, and the displacement of the tongue width was 0.26 mm. This result was within 1 SD of the average displacement of the representative subject of the pull-in pattern in the measurement experiment. The displacement of the mandibular gum-tongue tip distance between the “jaw-opening model” and the “centering model” was 1.67 mm, and the displacement of the tongue width was -5.57 mm. This result was within 1 SD of the average displacement of the representative subject of the “centering” pattern in the measurement experiment. The results of both the “pull-in” model and the “centering” model were consistent with the results of the measurement experiment. Therefore, the hypothesis that “pull-in” was the result of increased activity of SG and that the “centering” was the result of increased activity of T was supported in the simulation experiment. In the measurement experiment, many subjects increased the width of the tongue under the conditions (b) and (c). According to the result in the simulation experiment, these results was considered to be due to the effect of enhancing SG activity.

From the above results, the “pull-in” and “centering” pattern observed in Dysarthria patients were also observed in the compensatory movement of normal subjects. The pattern of Dysarthria patients' “pull-in” and “centering” should be considered not only for the possibility of motor abnormalities due to the neurological disease itself, but also for the compensatory movement of the motor abnormalities. It should be noted, however, that this study only examined compensatory movements under the limited conditions of the jaw opening position. In the future, it is necessary to conduct experiments on articulatory movement of / k / under more various conditions to study the universal production mechanism.