3. Evaluation of Swallowing Movement by Posture Change using Magnet-Impedance Sensor

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Introduction

The objective of this study is to develop a screening device for the swallowing difficulty using Magneto-Impedance sensor. VideoFluorography (VF) is effective to the diagnosis of swallowing difficulty. This diagnosis method is not effective to every patient. Because it has radiation exposure hazard, and is costly and takes long time for the diagnosis [1]. Consequently, an easy screening method has been widely used. The Repetitive Saliva Swallowing Test (RSST) is one of effective screening methods of the swallowing difficulty.

In this study, we developed the screening device to automate the RSST using a Magnet-Impedance sensor (MI sensor). And we verified whether the measurement of swallowing movement was possible by using the screening device. In addition, the influence of posture change on swallowing movement was evaluated by the change in subjects' posture when measuring it. Measurement result was different respectively by subject's posture change at measurement. We examined the posture that was appropriate for swallowing by analyzing measurement result.

However, the screening device seems to be hard to obtain enough result, because its body moves when swallowing. In this time, we did the measurement that used Three-Dimensional MI sensor as countermeasure of this problem.

Materials and Methods

The Repetitive Saliva Swallowing Test (RSST) is safe and simply screening method of the swallowing difficulty. It is performed by counting the frequency of swallowing over a 30 seconds. When the count of swallowing is less than 3 times/30 seconds, the subject is suggested to be further investigated for functional dysphagia by RSST [2].

We developed the screening device to automate the RSST. The screening device consists of a MI sensor and a magnet as shown in figure 1. Figure 2 shows the layout of the screening device on a patient. A magnet was attached on the larynx, and a MI sensor was attached on breastbone. The movement of magnet, which was the movement of the larynx according to swallowing, was detected with MI sensor as a change in the magnetic field. The output signal from MI sensor shows the movement of the larynx with swallowing.

In this time, we measured the swallowing movement by this method for healthy subjects and senior adult subjects. The screening device measured the swallowing movement, when subject was healthy people (figure 3). However, we were hard to obtain enough result, when subject was senior adults (figure 4). Because a MI sensor moved by body movement of senior adult, when swallowing. A MI sensor detects terrestrial magnetism besides the swallowing movement by this cause [3].

Consequently, we examined the influence of subjects' posture on swallowing movement by measuring it by various postures. We are expected that body movement when swallowing was suppressed by examining the posture that was appropriate for swallowing as a result of obtaining. In this time, we measured it by five kinds of posture of standing position, dorsal position, seated position, and cervix part bent position (the angle is 30 and 60 degrees).

In addition, we developed the screening device, using Three-Dimensional MI sensor as countermeasure of terrestrial magnetism by body movement. Figure 5 shows the layout of the

screening device using Three-Dimensional MI sensor. This screening device can detect swallowing movement in three directions. However, it is necessary to switch the axial direction by control program when measuring, because only one output pin was mounted on this MI sensor. In this time, we did two kinds of measurements. One was measurement that changed axis every 5 seconds. And the other was measurement that changed axis every 1 millisecond.

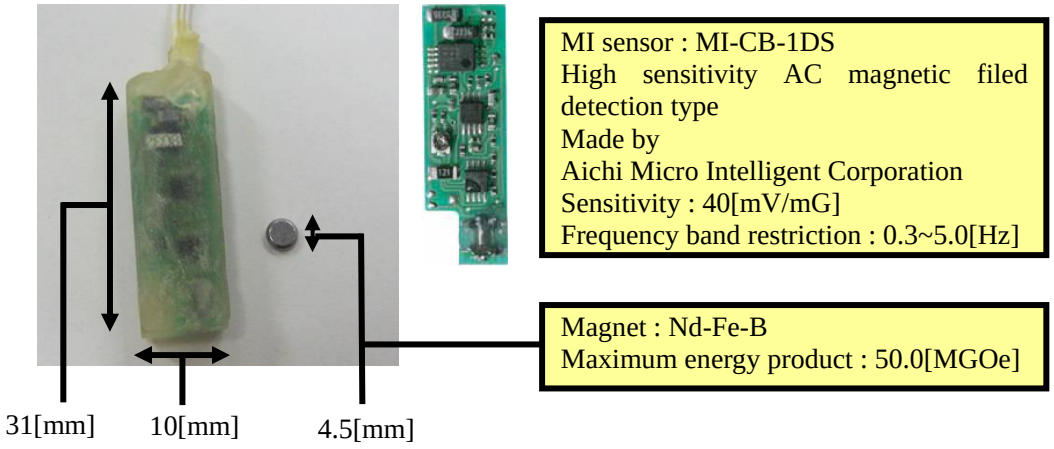


Figure 1 : The MI sensor and a magnet

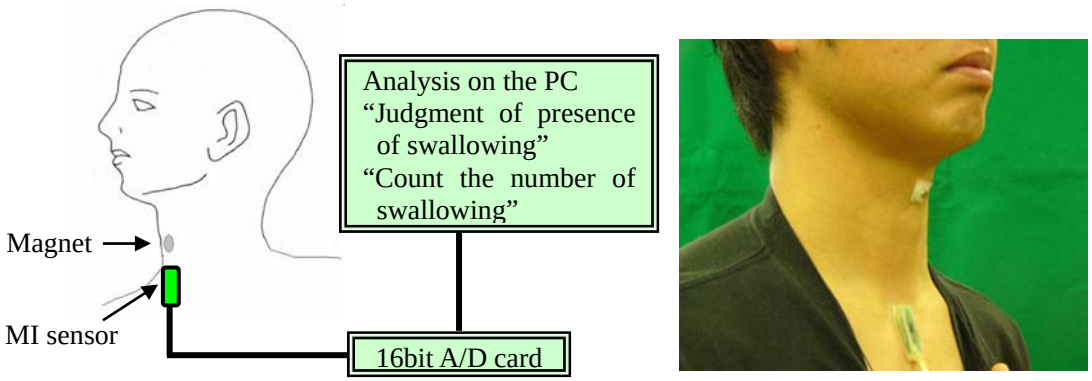


Figure 2 : The layout of the screening device

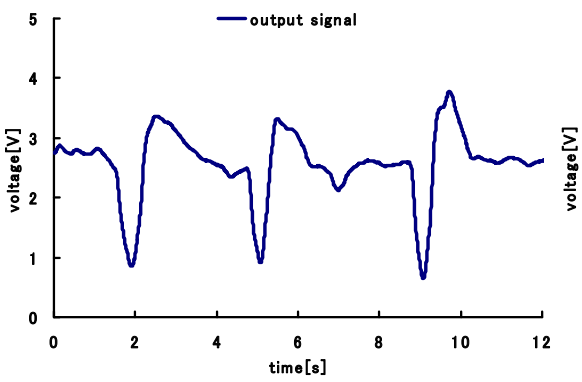


Figure 3 : Swallowing three times (healthy subject, male, 22 years old)

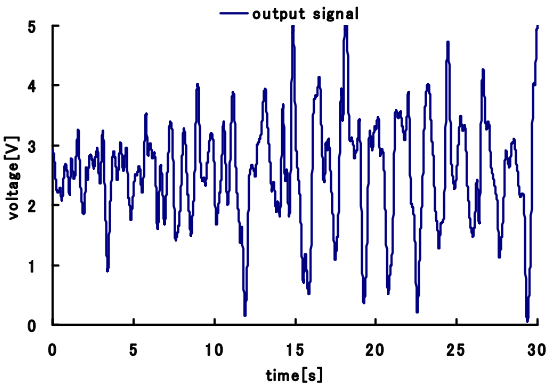
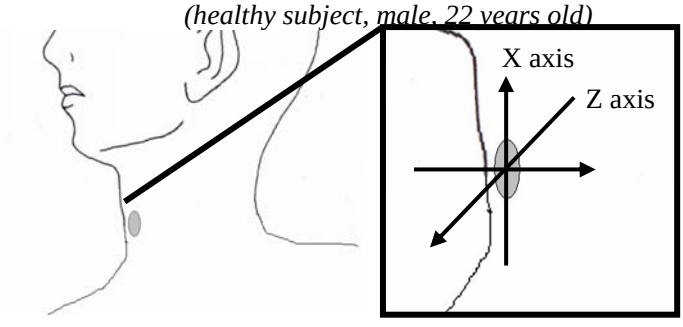


Figure 4 : Swallowing eight times (senior adult, male, 77 years old)



G_2 Motion sensor : AMI501
Made by
Aichi Micro Intelligent Corporation

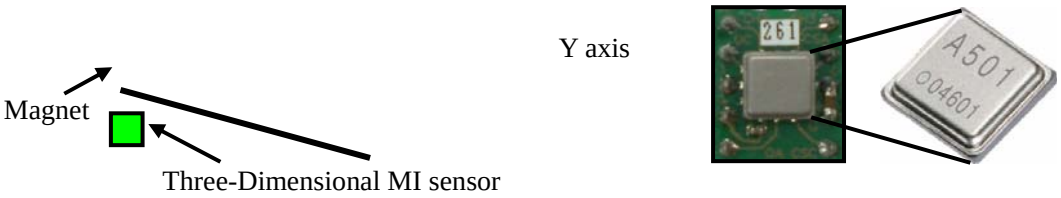


Figure 5 : The layout of the screening device (using Three-Dimensional MI sensor)

Results

Figure 6~9 show the measurement results when 24 years old male did swallowing in state of five kinds of posture (refer to figure 3 for the result in the state of seated position). A MI sensor could not detect swallowing movement accurately by the postures of standing position and dorsal position (figure 6, figure 7). On the other hand, a MI sensor detected swallowing movement accurately by the posture of cervix part bent position (figure 8, figure 9). The comparable result was obtained from the measurement intended for other healthy subject of several people.

Figure 10 shows the measurement result of using Three-Dimensional MI sensor when the axis changed every 5 seconds (figure 11). The larynx did movement different in each axis. Figure 12 and figure 13 show the measurement result when the axis changed every 1 millisecond (figure 14). The screening device made the terrestrial magnetism by sensor movement constant by calculating the absolute value of the output (figure 15).

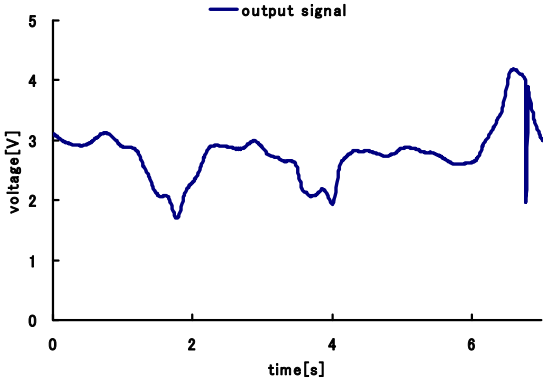


Figure 6 : Result by standing position

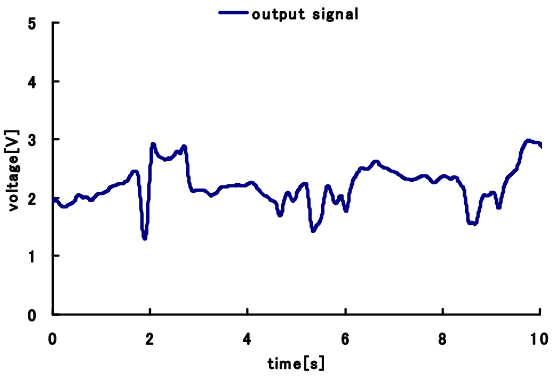


Figure 7 : Result by dorsal position

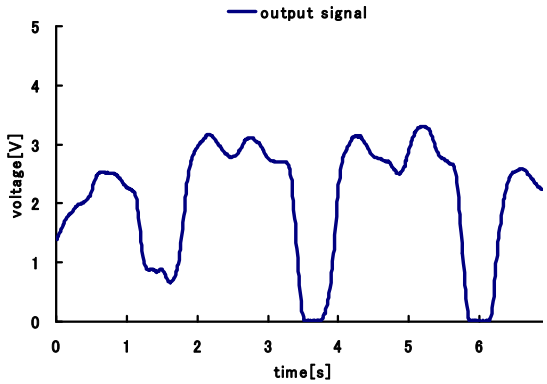


Figure 8 : Result by cervix part bent position (angle of posture is 30 degrees)

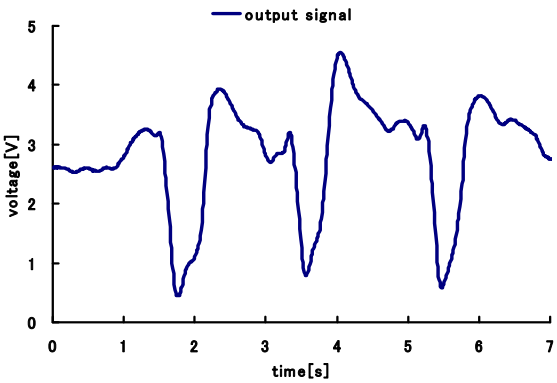
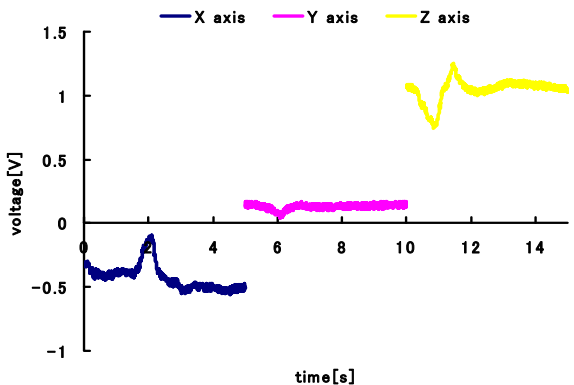


Figure 9 : Result by cervix part bent position (angle of posture is 60 degrees)



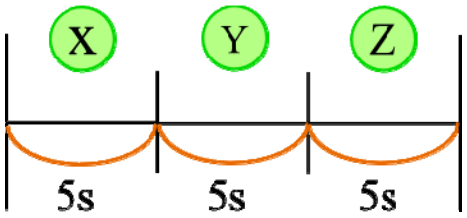


Figure 11 : The axis change every 5 seconds

Figure 10 : Result when the axis changed every 5 seconds

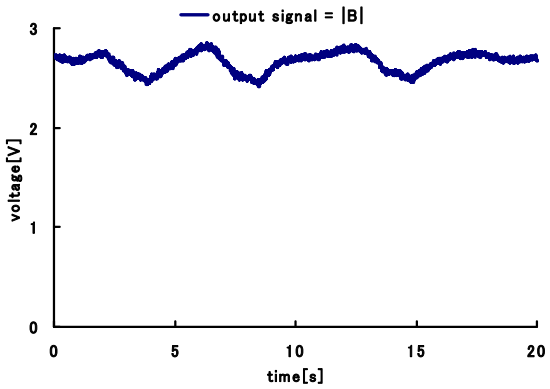


Figure 12 : Swallowing three times (when body was not moved)

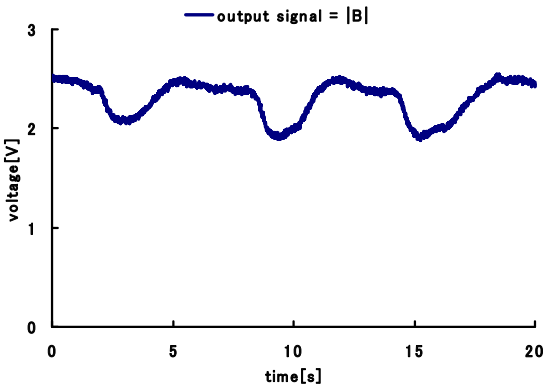


Figure 13 : Swallowing three times (when body was moved by intention)

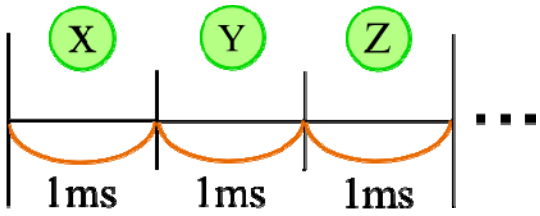


Figure 14 : The axis change every 1 millisecond

Value of terrestrial magnetism : B_0

Value of magnet movement : B_m

Value of output of sensor :

$$B = B_0 + B_m = B_X + B_Y + B_Z$$

Final output : $$|B| = \sqrt{B_X^2 + B_Y^2 + B_Z^2}$$

Figure 15 : Calculation of absolute value

Discussions

As a result of the analysis, swallowing movement appeared remarkably when subjects' posture was cervix part bent position (figure 8, 9). One reason of this result was considered that the subject's esophagus was expended by gravitation. The other reason was considered that subject's trachea was narrowed by gravitation [4]. For these reason, Cervix part bent position produced the best situation for swallowing.

In addition, the larynx greatly moved in the direction of Z axis (figure 10). Because, movement of epiglottis appeared remarkably to the direction of Z axis when swallowing.

The Three-Dimensional MI sensor did not influence body movement when swallowing, because figure 12 resembles figure 13 closely. Reason of this result was the Three-Dimensional MI sensor made the terrestrial magnetism by sensor movement constant, by the axis was changed fast (figure 14).

Conclusions

In this time, we developed screening device for the swallowing difficulty using Magnet-Impedance sensor. And we could measure the swallowing movement. In addition, we examined the influence of subjects' posture on swallowing movement. The results presented in this paper indicate that the most suitable posture for swallowing was cervix part bent position.

However, the screening device seems to be hard to obtain enough result, when patients' body moved when swallowing. To combat this problem, we measured the swallowing movement using the Three-Dimensional MI sensor, and made the terrestrial magnetism by sensor movement constant.

For the future, it is necessary to make the high precision analysis method, and to measure for the senior adults and patient.

References

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