

Examination of factors involved in predicting the prognosis of
oral intake recovery for inpatients with aspiration pneumonia
by videoendoscopic evaluation

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This doctoral thesis was prepared using the original article “Prediction of oral intake recovery for inpatients with aspiration pneumonia by videoendoscopic evaluation using the Hyodo-Komagane score in Japan” (Journal of Oral Rehabilitation, in press) with addition of new unpublished data on oral diadochokinesis.

Summary

Many patients hospitalized for aspiration pneumonia are discharged from the hospital in a state in which it is difficult to resume oral ingestion due to a decrease in swallowing function. Predicting whether the swallowing function will recover enough to resume oral ingestion at discharge is an important factor in developing a treatment strategy in hospitalized patients with aspiration pneumonia. The aim of this study is to describe a method for easy prediction of the prognosis for oral intake recovery using videoendoscopic examination of swallowing (VE), so that a decision can be made at an early stage about whether to undertake long-term tube feeding such as gastrostomy or early transfer to a rehabilitation hospital for patients who cannot resume oral ingestion in a short period of time.

Subjects were 65 patients who were admitted to an acute care hospital for the treatment of aspiration pneumonia. The subjects were all diagnosed by a respiratory physician, and underwent VE to determine if oral intake could be resumed. The resumption of oral intake and changes in the dietary form were decided by the attending physician based on the VE results and the nutrition support team conference results. The patients were divided into two groups, the oral feeding group and the tube feeding group, according to their oral intake status at discharge or transfer. The following items were obtained from the subjects' medical records: age, sex, albumin (Alb) at the time of hospitalization, history of cerebrovascular disease, neuromuscular disease, dementia, and presence of respiratory disease, C-reactive protein (CRP),

number of days from the date of hospitalization to the first VE test (non-intervention period), modified Rankin Scale (mRS) and Hyodo-Komagane score. In addition, oral diadochokinesis (ODK) was performed only on subjects who were able to follow the instructions.

The mRS score, Hyodo-Komagane total score, and pharyngeal clearance score of the oral feeding group were lower than those of the tube feeding group. Logistic regression analysis was performed using the condition that tube feeding was not required as an objective variable, and the items with significant differences between the two groups as explanatory variables. Additionally, the receiver operating characteristic curve was used to identify patients who could take food orally at discharge. The odds ratios for the Hyodo-Komagane score and the pharyngeal clearance score were 1.485 and 3.379, respectively. When the cut-off values of the Hyodo-Komagane score and the pharyngeal clearance score were 6 and 1, the sensitivity was 0.88 and 0.91, and the specificity was 0.64 and 0.70, respectively. Regarding the results of ODK, there were 22 subjects who were unable to pronounce the syllable as instructed. Therefore, excluding these subjects, the measurement value of 43 subjects (oral feeding group: 29, tube feeding group: 14) were analyzed. Comparing between the oral feeding group and tube feeding group, there was no statistically significant difference in ODK. Based on the above results, the following items were suggested in this study.

1. There was a significant difference in the mRS and Hyodo-Komagane score between the patients who needed tube feeding at discharge or transfer and those who did not.
2. Logistic regression analysis showed that the Hyodo-Komagane total score and the pharyngeal clearance score were significantly associated with the condition that tube feeding was not required at the time of discharge or transfer.
3. When the cut-off value of the Hyodo-Komagane total score is 6 or the pharyngeal clearance score is 1, these scores proved to be suitable for predicting whether patients with aspiration pneumonia need tube feeding at discharge or transfer.
4. The Hyodo-Komagane score, and especially the pharyngeal score item, are useful as an index to determine whether patients with aspiration pneumonia can resume oral intake during acute hospitalization.

Introduction

According to a study by the Ministry of Health, Labour and Welfare, pneumonia is one of the top causes of death in Japan [1]. More than 38,000 people died in 2017 as a result of aspiration pneumonia; this number is increasing year by year, and is estimated to reach 129,000 per year in 2030 [2]. Decreased swallowing function is a risk factor for aspiration pneumonia [3]. Momosaki et al. reported that 41% of patients who had been hospitalized for treatment of aspiration pneumonia found it difficult to ingest food orally within 30 days [4]. This finding suggests that many patients hospitalized for aspiration pneumonia are discharged from the hospital in a state in which it is difficult to resume oral ingestion due to a decrease in swallowing function.

Predicting whether the swallowing function will recover enough to resume oral ingestion at discharge is an important factor in developing a treatment strategy in hospitalized patients with aspiration pneumonia. In a previous study using big data, it was reported that the Barthel index on admission, underweight admission, and past history were useful as predictors of the prognosis for oral intake recovery within 30 days after admission for aspiration pneumonia [4]. Another study using videofluorography (VF) suggested that the penetration-aspiration scale (P-A scale) is useful for predicting whether or not nutrition can be completely taken orally after 4 weeks of VF, indicating the importance of conducting VF and performing nutritional management at an early stage of hospitalization [5]. However, VF requires large-

scale equipment, and it cannot be performed multiple times over a short period because of concerns about the exposure dose. However, videoendoscopic examination of swallowing (VE) requires only relatively simple equipment, and it can be performed multiple times regardless of location. Furthermore, unlike VF, it allows mucus accumulation in the pharynx and abnormal defense reflexes of the larynx to be evaluated. To date, there have been no studies about predicting the prognosis for oral intake recovery using VE for patients hospitalized with aspiration pneumonia. In this study, the factors that predict the prognosis for oral intake recovery were investigated using VE evaluation scale. The aim of this study was to describe a method for easy prediction of the prognosis for oral intake recovery, so that a decision can be made at an early stage about whether to undertake long-term tube feeding such as gastrostomy or early transfer to a rehabilitation hospital for patients who cannot resume oral ingestion in a short period of time.

Subjects and Methods

Subjects

Subjects were 65 patients who were admitted to Takasaki General Medical Center, an acute care hospital, for the purpose of treating aspiration pneumonia from 1 April 2018 to 31 March 2019. The subjects were all diagnosed by a respiratory physician, and underwent VE to determine if oral intake could be resumed. The subjects had different medical histories, but

were all nourished orally before admission. In this hospital, when patients suspected of having dysphagia are conscious without any stimulation and have stable vital signs, they are referred by the attending physician or the nutrition support team (NST) to a dentist for VE. If the patient's condition is poor on the day of the VE, the examination will be postponed as directed by the attending physician. The resumption of oral intake and changes in the dietary form are decided by the attending physician based on the VE results and the NST conference results. Additionally, detailed directions for meal assistance methods are placed at the bedside to ensure that all nurses in the ward are able to follow the instructions. If resumption of oral intake is not permitted, basic training is conducted by the NST and nurses, and the patient is again evaluated for swallowing function at the appropriate timepoint. This study was carried out in accordance with the Declaration of Helsinki with the approval of National Hospital Organization Takasaki General Medical Center (approval number: H30-35).

Data acquisition

The following items were obtained from the subjects' medical records: age, sex, albumin (Alb) at the time of hospitalization, history of cerebrovascular disease, history of neuromuscular disease, dementia, presence of respiratory disease, C-reactive protein (CRP), number of days from the date of hospitalization to the first VE test (non-intervention period), modified Rankin Scale (mRS) [6] and Hyodo-Komagane score [7]. The mRS is an index that

evaluates the degree of handicap. An absence of symptoms is evaluated as a score of 0, and a patient with a severe handicap, totally dependent and requiring constant attention night and day, is evaluated as a score out of 5. The Hyodo-Komagane score evaluates VE results with scoring from 0 to 3 points for four items: salivary pooling, glottal response (evaluation of laryngeal sensation), bolus location (evaluation of swallowing reflex induction), and pharyngeal clearance (Table 1). The Hyodo-Komagane score is evaluated based on the total scores of the four items. If it is less than 7, it is judged that oral intake is possible, and if it is more than 8, oral intake is difficult. In addition, the oral diadochokinesis (ODK) was performed only in subjects who were able to follow the instructions. The ODK evaluates the speed and regularity of articulation by repeatedly pronouncing a syllable as quickly as possible [8]. In this study, subjects were instructed to pronounce the syllable /ka/ as many times as possible for 5 seconds, and the examiner made dots on paper with a pen each time the syllable was heard, and counted and recorded them after the test.

Statistical analyses

Patients were classified into two groups according to their oral intake status at discharge or transfer: patients who were able to take necessary nutrients by oral ingestion without needing tube feeding (oral feeding group), and patients who needed tube feeding or central parenteral nutrition (tube feeding group). Numeric results were expressed as mean \pm

standard deviation. To compare differences between the two groups, an unpaired *t*-test (age, Alb, CRP, non-intervention period, and ODK) and a Mann-Whitney U-test (mRS and Hyodo-Komagane score) were used for parametric data and nonparametric data, respectively. The categorical variables (all other variables) were compared using chi-squared test. Additionally, to determine the factors useful for predicting the prognosis of oral intake status, logistic regression analysis was performed using the condition that tube feeding was not required at the time of discharge or transfer as an objective variable, and the items that showed significant differences in the comparison between the two groups as explanatory variables. The significance level was less than 5%. The receiver operating characteristic (ROC) curve was used to identify patients capable of oral ingestion at discharge. The area under the curve (AUC) and the accuracy of the examination were calculated. These statistical analyses were performed using SPSS Statistics Version 21 (IBM Japan, Tokyo, Japan).

Results

A total of 65 patients were included: 32 in the oral feeding group (22 men, 10 women) and 33 in the tube feeding group (21 men, 12 women). The average hospital stay was 26.1 ± 17.8 days. The characteristics of the oral feeding group and the tube feeding group are compared in Table 2. The mRS and Hyodo-Komagane score in the oral feeding group were lower than those of the tube feeding group. Additionally, amongst the four items of the Hyodo-Komagane

score, there were no significant differences between the two groups in salivary pooling, glottal response, and bolus location at the time of swallow, but there was a significant difference in the pharyngeal clearance score. Simple linear regression analysis to examine the relationship between the research items with significant differences and the status of no need for tube feeding at the time of discharge or transfer revealed that all items were significantly different (Table 3). Based on these findings, logistic regression analysis was conducted using mRS, Hyodo-Komagane score, and the pharyngeal clearance score as the explanatory variables. However, since multicollinearity was suspected for the Hyodo-Komagane total score and the pharyngeal clearance score, logistic regression analysis with mRS and Hyodo-Komagane score as the explanatory variables was undertaken as model 1, and logistic regression analysis with mRS and pharyngeal clearance score as the explanatory variables was performed as model 2. In model 1, there was a significant difference in the Hyodo-Komagane score, and the odds ratio was 1.485. In model 2, there was a significant difference in the pharyngeal clearance score, and the odds ratio was 3.379 (Table 4). The cut-off value of the Hyodo-Komagane total score calculated from the ROC curve (Fig. 1) was 6, with a sensitivity of 0.88, specificity of 0.64, and AUC of 0.774. The cut-off value of the pharyngeal clearance score calculated from the ROC curve (Fig. 2) was 1, with a sensitivity of 0.91, specificity of 0.70, and AUC of 0.826. The results of the ODK showed that there were 22 subjects who were unable to pronounce the syllable as instructed. After excluding these subjects, the scores of 43 subjects (oral feeding

group: 29, tube feeding group: 14) were analyzed. The ODK rates in the oral feeding group and the tube feeding group were 3.9 ± 0.99 and 3.5 ± 1.05 counts per second, respectively. No statistically significant difference was observed between the two groups (Fig. 3).

Discussion

The factors that predict the prognosis of oral intake status at discharge or transfer for patients hospitalized with aspiration pneumonia were investigated using VE evaluation scale. This results showed that the mRS score, Hyodo-Komagane total score, and pharyngeal clearance score of the oral feeding group were lower than those of the tube feeding group. These findings indicate that there was a significant difference in the initial VE findings between the patients who needed tube feeding at discharge or transfer and those who did not. Additionally, logistic regression analysis showed that the Hyodo-Komagane total score and the pharyngeal clearance score were significantly associated with the condition that tube feeding was not required at the time of discharge or transfer. Furthermore, when the cut-off value of the Hyodo-Komagane total score is 6 or the pharyngeal clearance score is 1, these scores proved to be suitable for predicting whether patients with aspiration pneumonia need tube feeding at discharge or transfer.

In contrast, the ODK results showed no statistically significant difference between the oral feeding group and the tube feeding group. The number of ODK counts decreased with age,

and the frail group had a significantly lower ODK rate than the robust group [9]. The Japanese Society of Gerodontology defines an ODK rate of less than 6 per second as characteristic of decreased tongue-lip motor function, and proposes that it is a symptom of oral hypofunction [10]. Of the 43 subjects in this study, 41 (oral feeding group: 28, tube feeding group: 13) had a rate of less than 6 per second; that is, most patients had decreased tongue-lip motor function, regardless of oral intake recovery. Therefore, ODK rate is not appropriate as a factor to predict the prognosis of oral intake status.

Oba et al. reported that the Glasgow Coma Scale and Repetitive Saliva Swallowing Test [11] can easily predict the prognosis of whether or not oral intake is possible in acute pneumonia [12]. However, the previous study was not limited to aspiration pneumonia. In our study, subjects were not included until their level of consciousness improved enough to tolerate oral intake. Therefore, this study differs from the previous study in terms of the causative disease of the patients and the timing of the evaluation of the swallowing function. Previous studies limited to aspiration pneumonia have conducted research using big data [4] and VF findings [5]; however, none of these reports indicated whether their survey items with significant differences were suitable screening tests to predict the prognosis of oral intake status for patients with aspiration pneumonia. This study is therefore the first to suggest that the Hyodo-Komagane score may be useful as a screening test for prognostic prediction.

Each item of the Hyodo-Komagane score is suitable for evaluating the swallowing function of dysphagic patients during tube feeding. As stated by Hyodo et al., this method of evaluation is useful because it can be easily judged even by an examiner who is not a specialist in dysphagia [13]. Sakamoto et al. reported that the best criterion for starting oral ingestion is a total score of 7 or less for each item. Additionally, Sakamoto et al. noted the importance of the pharyngeal clearance item, arguing that with a pharyngeal clearance score of 3, initiation of oral ingestion should be avoided regardless of the score of other items [7].

Among the evaluation items in the Hyodo-Komagane score, this study found that salivary pooling, glottal response (laryngeal sensation), and bolus location (swallowing reflex induction) were not significantly different; only the pharyngeal clearance score was significant. All items were considered important for evaluation, but our results showed that pharyngeal clearance was particularly important. Decreased pharyngeal clearance is a common symptom in dysphagia patients with cerebrovascular disease and neurological disorders. However, this study found no significant association between these disorders and the recovery of oral intake. Recent studies have reported that pharyngeal clearance is likely to decrease in patients with sarcopenia due to the enlarged pharyngeal cavity [14], weaker pharyngeal contractility, and upper esophageal sphincter dysfunction [15]. However, the data of sarcopenia-related was not taken in this study. Therefore, it is necessary to further investigate the association between sarcopenia and oral intake recovery in patients with aspiration pneumonia in the future.

There are several limitations in this study. First, sarcopenia-related items were not measured. Additionally, although swallowing function was assessed using VE, no other tests such as tongue pressure were performed. Therefore, the number of measurement items should be increased in future surveys. Second, this study was conducted in one hospital, and the characteristics of this hospital may have affected the results. Additionally, the hospital where the survey was conducted was an acute care hospital, so the patients were discharged or transferred on average after about a month, regardless of whether they were capable of oral ingestion. For this reason, it is possible that there were some patients who did not need tube feeding after undergoing rehabilitation for a long time after transferring to this hospital. In other words, the results of this study can serve as an index to determine whether patients hospitalized for aspiration pneumonia can recover to a state where tube feeding is unnecessary in a short period, but it is not an indicator to determine the long-term final prognosis. However, for patients whose tube feeding is predicted to be necessary for a long period of time based on the results of this study, so the attending physician should change to a method of tube feeding that is suitable for long-term nutrition management such as gastrostoma, or transferring patients to a convalescent hospital that can focus on swallowing rehabilitation at an early stage.

Conclusion

In this study, the effectiveness of videoendoscopic evaluation using the Hyodo-Komagane score in prediction of oral intake recovery for inpatients with aspiration pneumonia was examined, and the following items were suggested.

1. There was a significant difference in the mRS and Hyodo-Komagane score findings between the patients who needed tube feeding at discharge or transfer and those who did not.
2. Logistic regression analysis showed that the Hyodo-Komagane total score and the pharyngeal clearance score were significantly associated with the condition that tube feeding was not required at the time of discharge or transfer.
3. When the cut-off value of the Hyodo-Komagane total score is 6 or the pharyngeal clearance score is 1, these scores proved to be suitable for predicting whether patients with aspiration pneumonia need tube feeding at discharge or transfer.
4. The Hyodo-Komagane score, and especially the pharyngeal score item, are useful as an index to determine whether patients with aspiration pneumonia can resume oral intake during acute hospitalization.

Acknowledgments

The author sincerely thanks all members of the nutrition support team of the National Hospital Organization Takasaki General Medical Center who cooperated in this study.

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Tables and Figures

Table 1 Hyodo-Komagane score

Hyodo-Komagane score
A: Salivary pooling in vallecular and piriform sinuses
0 – No pooling
1 – Pooling at the only vallecula
2 – Pooling in vallecula and piriform sinuses and no penetration* into larynx
3 – Pooling in vallecula and piriform sinuses and penetration* into larynx
B: The response of glottal closure reflex induced by touching the epiglottis with the endoscope
0 – Marked reflex in response to one touch
1 – Slow and/or weak reflex in response to one touch
2 – Reflex in response to two or three touches
3 – No reflex despite three touches
C: The location of the bolus at the time of swallow onset assessed by “white-out”** following swallowing of test jelly
0 – Pharyngeal
1 – Vallecula
2 – Piriform sinuses
3 – No swallowing
D: The extent of pharyngeal clearance after swallowing of test jelly
0 – No residues
1 – Pharyngeal residues remain, but are absent after swallowing is attempted two or three times
2 – Pharyngeal residues remain, but do not penetrate into larynx
3 – Pharyngeal residues remain and penetrate into larynx
* When saliva or test jelly enters the glottis (opening to the trachea) and moves as far as the vestibule above the true vocal folds, this is termed as “penetration”.
** “White-out” is defined as the period when the videoendoscopic image is obscured owing to pharyngeal closure.
Total score (A+B+C+D) = 0–12

Table 2 Comparison between the oral feeding group and the tube feeding group

	ALL (n=65)	oral feeding group (n=32)	tube feeding group (n=33)	P-value	OR	95%CI
Age (SD)	81.4 (8.7)	79.9 (8.66)	82.9 (8.47)	0.08	1.04	0.98-1.11
~59	0	0	0			
60~69	8	6	2			
70~79	13	7	6			
80~89	33	15	18			
90~	11	4	7			
Men	43	22	21	0.86	1.26	0.45-3.52
Clinical backgrounds						
cerebrovascular disease	20	10	10	1.00	0.96	0.33-2.74
neurological disorder	13	5	8	0.58	1.73	0.50-5.99
dementia	46	19	27	0.09	3.08	0.99-9.55
lung disease	10	6	4	0.69	0.60	0.15-2.36
Alb value (SD)	3.13 (0.6)	3.22 (0.7)	3.04 (0.6)	0.12	0.61	0.27-1.36
CRP (SD)	13.4 (9.0)	12.3 (7.8)	14.4 (9.8)	0.17	1.03	0.97-1.09
Non-intervention period (SD)	5.5 (6.4)	4.5 (5.8)	6.5 (6.8)	0.10	1.06	0.97-1.16
mRS (SD)	4.1 (1.1)	3.8 (1.0)	4.4 (1.0)	<0.01	1.76	1.05-2.95 *
Hyodo-Komagane Score (SD)	5.3 (2.8)	3.9 (2.2)	6.6 (2.6)	<0.01	1.52	1.21-1.92 *
A:salivary pooling (SD)	2.0 (1.2)	1.7 (1.2)	2.2 (1.1)	0.06	1.46	0.95-2.23
B:response (SD)	0.8 (0.9)	0.7 (0.8)	1.0 (1.0)	0.10	1.62	0.91-2.87
C:the time of swallow (SD)	1.1 (1.0)	0.9 (0.9)	1.2 (1.0)	0.25	1.39	0.83-2.33
D:pharyngeal clearance (SD)	1.4 (1.2)	0.7 (0.8)	2.1 (1.1)	<0.01	3.61	1.98-6.55 *

* $P < 0.01$

Abbreviations: SD, standard deviation; Alb, serum albumin; CRP, C-reactive protein; mRS, modified Rankin Scale; OR, odds ratio; CI, confidence interval

Table 3 Univariable analysis

Variabels	OR	95% CI	SE	<i>P</i> -value
mRS	1.764	1.054-2.952	0.263	0.031
Hyodo-Komagane Score	1.524	1.207-1.924	0.119	<0.001
pharyngeal clearance	3.605	1.983-6.552	0.305	<0.001

Abbreviations: mRS, modified Rankin Scale; OR, odds ratio; CI, confidence interval; SE, standard error

Table 4 Multivariable analysis

Variabels	OR	95% CI	SE	<i>P</i> -value
Model 1				
mRS	1.494	0.840-2.657	0.294	0.172
Hyodo-Komagane Score	1.483	1.168-1.882	0.122	0.001
Model 2				
mRS	1.421	0.770-2.624	0.313	0.261
pharyngeal clearance	3.379	1.857-6.149	0.305	<0.001

Abbreviations: mRS, modified Rankin Scale; OR, odds ratio; CI, confidence interval; SE, standard error

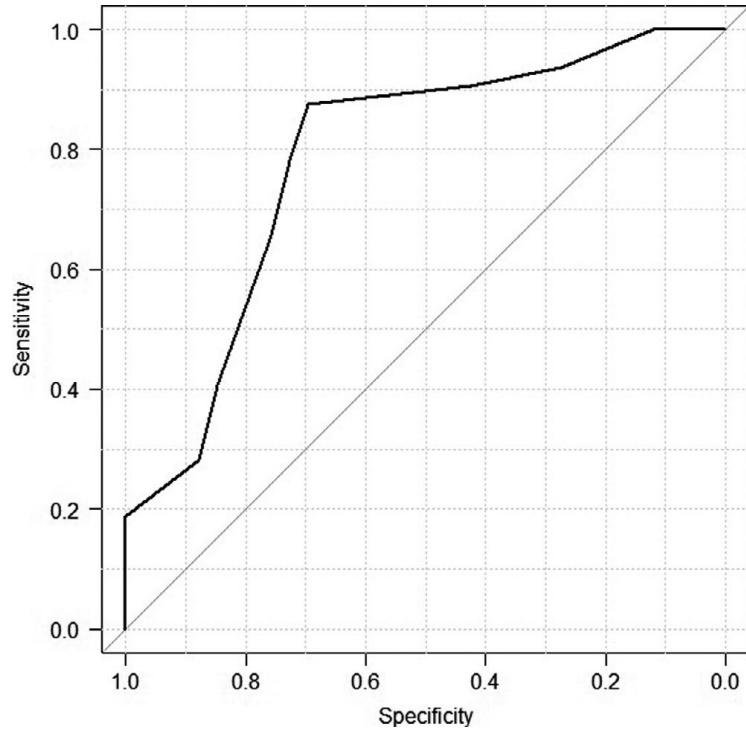


Fig. 1 ROC curves to predict oral intake by the Hyodo-Komagane total score

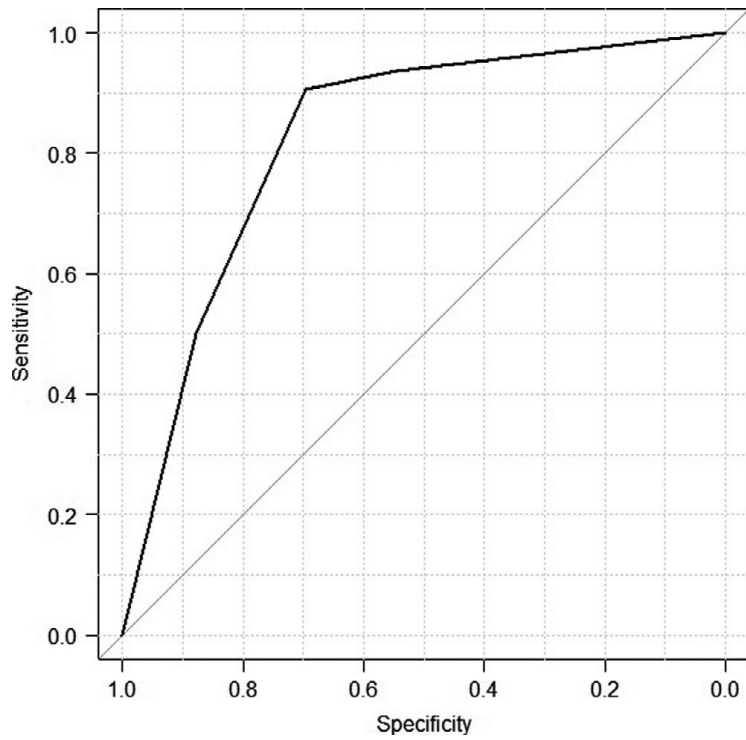


Fig. 2 ROC curves to predict oral intake by the pharyngeal clearance score

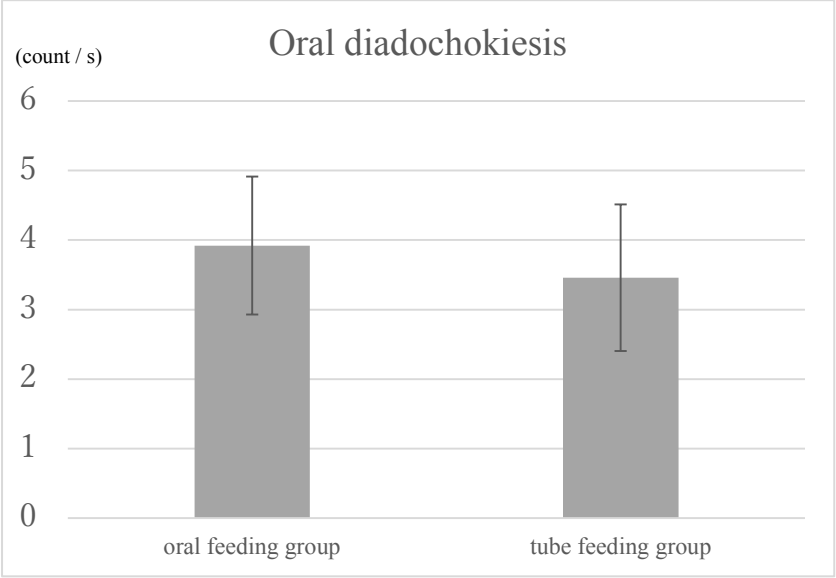


Fig. 3 Comparison of oral diadochokinesis counts