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1. Introduction

Masticatory disorder is a cause of malnutrition [1] and choking [2] among older individuals requiring long-term care, and thus has a major impact on life prognosis [3]. The presence of occlusal support and the number of teeth present have been shown to be involved in the maintenance of masticatory function [4,5]; therefore, it is important to prevent dental diseases in older individuals to help them maintain a good quality of life.

In addition to occlusal support and the number of teeth present, oral motor function influences masticatory function [6,7]. Oral function, including tongue motor function, declines with age [8] and can be impaired by sequelae of cerebrovascular or neurodegenerative diseases [9]. For these reasons, in older people especially, it is necessary to address not only masticatory disorders caused by tooth loss (organic masticatory disorder) but also masticatory disorders resulting from a decline in oral function (motor masticatory disorder) [6]. Decline in coordinated movement while eating, principally in the lips, tongue, cheeks, and mandible, causes a decrease in masticatory performance, making bolus formation difficult. As a result, food enters the pharynx while in a state of incomplete mastication, increasing the risk of choking and aspiration. In Japan, approximately 4,000 people die every year from choking on food [10], and masticatory disorder is suspected to be a contributing factor. To prevent such choking and aspiration in older people or patients with dysphagia, the physical properties and size of the food ingested needs to be modified [11,12].

For older individuals with decreased muscle strength, ill-fitting dentures, or inadequate masticatory ability, tender food that can easily be crushed by chewing is recommended.

In addition, for individuals who cannot perform grinding movements with their molars due to issues with tongue rotation and lateral movement, food with a soft consistency that can be squeezed

Abstract

Purpose: This study aimed to develop a simple screening test for mastication, “the Sakiika (squid jerky) transport test (STT), which evaluates the vertical jaw movement coordinated with the lateral tongue movement during stage I transport, and investigate the possibility of its clinical application.

Methods: The study included 73 people with dysphagia (mean age, 78.5 ± 7.8 years; median age, 79.0 years; interquartile range, 75.0–84.0). The STT evaluated the ability of a participant to transport a piece of squid jerky placed on the midline of the tongue to the molar region. The STT score was defined as the number of vertical jaw movements occurring as the tongue transported food to the molars. A cutoff value was set by comparing the STT scores with masticatory function evaluated via a videofluoroscopic swallowing study and with food texture evaluated using the Food Intake LEVEL Scale (FILS).

Results: The STT scores counted by the two examiners had a κ coefficient of 0.79, indicating good reliability. The STT score was significantly associated with both the presence of masticatory movement (\(p = 0.019\)) and food texture classified by FILS (\(p = 0.032\)) at cutoff value of “3” (3 vertical movements). The STT showed 62% sensitivity and 75% specificity for masticatory movements.

Conclusion: The STT could be a useful screening test to assess the presence or absence of food transportation to the molars for mastication in older patients with dysphagia. In addition, the STT could be useful in identifying the need to modify food texture to meet functions.

Keywords: Dysphagia, Mastication, Oral function, Stage I transport, Tongue movement
by pressing it with the tongue against the palate is recommended. For individuals who have difficulty with this method, pureed or finely chopped food that can be swallowed directly is recommended. Such food texture types should be determined based on an assessment of oral function. Oral function tests that have been reported include evaluation methods using tongue pressure, bite force, or masticatory efficiency [13-15]. However, it is difficult to conduct these oral function tests in patients with issues such as severe cerebrovascular disease or dementia, as they are often unable to follow the examiner's instructions [16]. Moreover, detailed examinations using videofluoroscopy or video endoscopy are highly reliable assessments of swallowing function, but many facilities are unable to perform these examinations due to lack of equipment or other reasons.

When solid food requiring mastication is ingested, the first movement observed is stage I transport [17,18]. In stage I transport, food ingested in the midline at the maximal jaw opening is pulled backward by the tongue, lifted upwards by elevation of the tongue surface, and pushed laterally against the occlusal surfaces of the molars by the rotation of the tongue. Stage I transport is considered to be complete when the jaws close [19]. In this study we focused on the jaw movement of stage I transport. We considered that the number of tongue rotations and lateral movements necessary for transporting food from the middle of the tongue surface to the occlusal surface of the molar region was related to the number of vertical jaw movements, and that an increase in the number of jaw movements would indicate the degree of difficulty in the onset of masticatory movement. The purpose of this study was to develop a new oral function test to count the jaw movements required for transporting test food to the molar region and to verify whether this test would be useful for evaluating the tongue rotation and lateral movement required for mastication.

2. Materials and methods

2.1. Participant characteristics

The subjects consisted of 108 patients aged ≥60 years who presented to the outpatient clinic with a chief complaint of dysphagia and were assessed for swallowing function via a videofluoroscopic swallowing study (VFSS) throughout October 2019 to March 2020.

The primary disease-causing dysphagia and dental charts of each patient were collected from their medical records. Thirty-five patients were excluded from the study for the following reasons: (1) they could not eat soft food due to dysphagia (19 cases), (2) they were classified as Eichner [20] B-4 or C (10 cases), and (3) they had no anterior tooth contact (6 cases). Ultimately, 73 patients (44 men and 29 women) with a mean age of 78.5 ± 7.8 years were selected to participate.

The participants were characterized by evaluation of their activities of daily living (ADL), eating function, and cognitive function. ADL was evaluated using the Barthel index [21], with a score ranging from 0 to 100, to which either the participant or their guardian responded. Evaluation of eating function was performed using the Food Intake LEVEL Scale (FLIS) [22], which evaluates the severity of dysphagia as follows: Levels 1–3, no oral intake; Levels 4–6, oral intake and alternative nutrition; Levels 7–9, total oral intake; and Level 10, within a normal range. Levels 4–7 indicate oral intake of easy-to-swallow food even without mastication [22]. Cognitive function was evaluated using the Mini-Mental State Examination (MMSE) [23], with scores ranging from 0 to 100, to which either the participant or their guardian responded.

2.2. Sakiika (squid jerky) transport test (STT)

The test food used in this study was commercially available sakiika (dried squid jerky; Takuma Foods Co., Aichi, Japan). It was cut in half, with the resulting pieces measuring 108 mm x 9.0 mm x 2.0 mm (Fig. 1). Dry-processed squid jerky was selected to prevent accidental ingestion or aspiration as it would not be easily bitten through. During the STT, the examiner filmed the movements of the lips, tongue, and jaw of the participant using a video camera (HDR-CX680; Sony, Tokyo, Japan) held in a fixed position and recorded in AVCHD format. The participant was seated in a relaxed state with one end of the test food (3 cm from the edge) placed on the midline of the tongue surface. The examiner lightly held a different side of the test food and instructed the participant to chew the food with their molars. The examiner gave no directions regarding which side of the mouth the participant should transfer the test food. The number of vertical jaw movements made by the participant in coordination with the tongue when transporting the test food from the midline to the molar region (STT score) was counted using the video recording. Counting was performed by two dentists (Examiners A and B), both of whom were unaware of the feeding and swallowing abilities of the participants. Examiner A was a dentist specializing in dysphagia rehabilitation, and Examiner B was a dentist with no experience in dysphagia rehabilitation. The measured values were based on data from Examiner A.

2.3. Masticatory ability evaluation by videofluoroscopic swallowing study (MEVF)

VFSS was performed using a fluoroscope for evaluation of masticatory ability (VC-1000; Hitachi Medical Corp., Tokyo, Japan). Considering the risks of aspiration and possibility of choking on bite-sized pieces of food [11] a frustum (with a square base measuring 15.0 x 15.0 mm; weight, approx. 4 g) was used in the VFSS to lower the risk of choking. The test food was prepared by shaking 100 ml of water with 50 g of barium sulfate (Baritop P; Kaigen Pharma Co. Ltd., Osaka, Japan), 20 g of granulated sugar, and 6.8 g of gelling agent (Softia Tes Cup; NUTRI Co. Ltd., Mie, Japan). Figure 2 shows the fork pressure
2.4. Oral function testing

From the STT by a dentist specializing in dysphagia rehabilitation. Masticatory movement was performed in a blinded manner separate from the mastication group (level 7 or lower) and food with mastication was a) masticated, b) only mashed by the tongue pushing it against the hard palate [24], or c) swallowed whole. Participants deemed to have masticated the food were assigned to the non-masticating group. Based on the FILS, participants were classified into a texture-modified diet (TMD) with maximum effort for 7 s. Measurements were taken three times, and the peak value was recorded.

2.4.1. Tongue pressure test

Tongue pressure, which refers to the force exerted by the tongue against the palate, was measured using a plastic balloon probe and a tongue pressure instrument (TPM-01; JMS Co., Hiroshima, Japan) following the method of Tsuga et al. [25]. Participants were seated and instructed to press the balloon with the tongue against the palate with maximum effort for 7 s. Measurements were taken three times, and the peak value was recorded.

2.4.2. Oral diadochokinesis test

The speed of the lip and tongue movements was measured using an oral function analyzer (T.K.K. 3351; Takei Scientific Instruments, Tokyo, Japan). Participants were asked to pronounce the /pa/, /ta/, and /ka/ sounds as quickly as possible for 5 s each. Each sound was measured once, and the number of times the words were pronounced per second was recorded [26].

2.4.3. Bite force test

The bite force, which represents the strength of the masticatory muscles, was measured using a pressure-sensitive film for bite force measurement systems (Dental Prescale II; GC Corp., Tokyo, Japan). The participants were seated, and the pressure-sensitive film was lightly placed between the upper and lower dental arches. Participants were instructed to bite the pressure-sensitive film as hard as possible for 3 s when cued by the examiner. The pressure-sensitive film was then scanned by a designated device and inputted to a computer. Bite force was analyzed using bite force analysis software (Bite Force Analyzer; GC Corp.) [27].

2.4.4. Masticatory performance test

Masticatory performance was evaluated using gummy jellies containing glucose according to the method described by Shiga et al. [13]. Participants were seated and instructed to chew a gummy jelly on their preferred chewing side for 20 s. After that, the participants were instructed to hold 10 mL of distilled water in their mouth, and then spit the water into a filtered cup. The glucose content of the filtered extract was measured using a measuring device (Gluco Sensor GS-II; GC Corp.) to determine masticatory performance.

2.5. Statistical analysis

First, we evaluated the effect of cognitive function on the ability to perform each test. For each oral function test, participants were divided into performing and non-performing groups. The Mann-Whitney U test was used to compare the MMSE scores between the two groups for each test. For the STT, participants were divided into transporting and non-transporting groups, and MMSE scores between these two groups were also compared.

Next, the reliability of the STT was evaluated by calculating the κ coefficient of inter-examiner reliability in the STT score. Several cut-off values were set for the STT score, and they were classified into two groups according to the cutoff values. Participants who could not transfer the test food or whose STT score was above the cutoff value were classified into the high score/non-transport group, and those with STT scores below the cutoff value were classified into the low score group. Based on the MEVF, participants were also classified into masticating and non-masticating groups. Based on the FILS, participants were classified into a texture-modified diet (TMD) without mastication group (level 7 or lower) and food with mastication group (level 8 or higher). To examine the cutoff value for STT, the two STT score groups and the two MEVF groups were compared using Fisher's exact test and the Youden index [28]. Furthermore, the STT score classifications that showed significant differences were compared with the two FILS groups using Fisher's exact test.

The sample size was calculated using G*Power 3.1 for Windows (Kiel University, Kiel, Germany) [29], with the a level (type I error) set at p = 0.05, and the power (type II error) set at 0.80. The effect size was assumed to be 0.30 (moderate). Accordingly, an analysis with ≥88 participants was planned.

Data were analyzed using the Japanese version of SPSS for Windows version 26.0 (IBM Corp., Armonk, NY). All results were presented...
Table 1. Oral function test results of participants who were able to perform each test.

| Test                                      | n  | median   | IQR       |
|-------------------------------------------|----|----------|-----------|
| Tongue pressure (kPa)                     | 67 | 25.0     | 19.2-30.4 |
| Oral Diadochokinesis’ /pa/ (times/s)      | 69 | 5.4      | 4.4-6.0   |
| Oral Diadochokinesis’ /ta/ (times/s)      | 68 | 5.2      | 4.4-6.0   |
| Oral Diadochokinesis’ /ka/ (times/s)      | 68 | 4.8      | 3.7-5.6   |
| Bite force (N)                            | 68 | 383.5    | 217.5-730.9 |
| Masticatory performance (mg/dL)           | 66 | 133.5    | 86.0-188.0 |
| STT score                                 | 66 | 1.5      | 1.0-2.3   |
| 1 time                                    | 33 |          |           |
| 2 times                                   | 17 |          |           |
| 3 times                                   | 11 |          |           |
| over 4 times                              | 5  |          |           |
| Non-transporting                          | 7  |          |           |
| MEVF                                      | 73 |          |           |
| Performed mastication                     | 60 |          |           |
| Push mashed food with the tongue and anterior hard palate | 8  |          |           |
| Swallowed whole food                      | 5  |          |           |

IQR; Interquartile Range, STT; Sakiika transport test, MMSE; Mini-mental state examination, MEVF; Masticatory ability evaluation by VFSS

as the median and interquartile range (IQR) since the data showed a non-normal distribution. A significant difference was set as α = 0.05.

2.6. Ethical approval

This study conformed to the principles described in the World Medical Association Declaration of Helsinki (2002) and was approved by the ethics committee of Nippon Dental University (NDU-T2018-10). Informed consent was obtained from all patients or their legal guardians.

3. Results

3.1. Participants

The median age of the 73 participants was 79.0 years (IQR: 75.0–84.0 years), and the mean age (± standard deviation) was 78.5 ± 7.8 years. Of these, 44 participants (60.3%) were men. The primary diseases that caused dysphagia were cerebrovascular disease (21 cases), progressive neuromuscular disease (13 cases), oropharyngeal cancer (4 cases), gastric or esophageal cancer (2 cases), and diseases classified as “other” (34 cases). The median value of the Barthel index was 100.0 (IQR: 80.0–100.0). For FILS, 1 participant was level 5, 1 participant was level 6, 20 participants were level 7, 44 participants were level 8, and 7 participants were level 9. The test scores of the participants able to perform each test are listed in Table 1. Of the participants able to transport the test food to the molar region: 33 received score 1 on the STT, 17 scored 2, 11 scored 3, and 5 scored ≥4. Seven participants were unable to transport the test food. The median STT score of the 66 participants able to transport the food was 1.5 (IQR: 1.0–2.3). In the MEVF, 60 participants masticated the test food, 8 only squeezed the food with the tongue, and 5 swallowed the food whole.

Table 2. Comparison of MMSE score between participants who could and could not perform oral function tests.

| Test                                      | Performing | Non-performing | p      |
|-------------------------------------------|------------|----------------|--------|
| n median   | IQR     | n median   | IQR     |
| Tongue pressure test                      | 67  | 25.0 | 19.2-30.4 | 6   | 13.0 | 3.0-20.5 | 0.000 |
| Oral Diadochokinesis’ /pa/ (times/s)      | 69  | 5.4  | 4.4-6.0   | 4   | 7.5  | 1.0-14.0 | 0.001 |
| Oral Diadochokinesis’ /ta/ (times/s)      | 68  | 4.8  | 3.7-5.6   | 5   | 11.0 | 2.0-20.5 | 0.002 |
| Oral Diadochokinesis’ /ka/ (times/s)      | 68  | 383.5 | 217.5-730.9 | 5 | 11.0 | 2.0-17.5 | 0.000 |
| Masticatory performance (mg/dL)           | 66  | 133.5 | 86.0-188.0 | 7 | 15.0 | 4.0-23.0 | 0.001 |
| STT score                                 | 66  | 1.5  | 1.0-2.3   | 0   |      |          |        |
| 1 time                                    | 33  |      |           |     |      |          |        |
| 2 times                                   | 17  |      |           |     |      |          |        |
| 3 times                                   | 11  |      |           |     |      |          |        |
| over 4 times                              | 5   |      |           |     |      |          |        |
| Non-transporting                          | 7   |      |           |     |      |          |        |
| MEVF                                      | 73  | 26.0 | 22.0-29.0 | 0   |      |          |        |
| Performed mastication                     | 60  |      |           |     |      |          |        |
| Push mashed food with the tongue and anterior hard palate | 8  |      |           |     |      |          |        |
| Swallowed whole food                      | 5   |      |           |     |      |          |        |

IQR; Interquartile Range, STT; Sakiika transport test, MEVF; Masticatory ability evaluation by VFSS

3.2. Comparison of MMSE score between participants who could and could not perform oral function tests

Table 2 shows a comparison using the Mann-Whitney U test of MMSE scores for the participants who could and could not perform the STT or other oral function tests. Except for the STT and MEVF, the MMSE scores for all oral function tests were significantly lower in the non-performing group than in the performing group.

The median MMSE score of the 73 participants who could perform the STT was 26.0 points (IQR: 22.0–29.0). In the STT, the median MMSE score of the 66 participants able to transport the test food was 26.0 points (IQR: 22.0–29.0), and the median MMSE score of the 7 participants unable to transport the test food was also 26.0 points (IQR: 18.0–27.0). There was no significant difference between the two groups (p = 0.43).

3.3. Reliability between the STT examiners

For STT scores, the two examiners agreed on 61 of the 73 participants (83.6%). The examiners’ agreement on the STT scores was 0.79.

3.4. Examination of cutoff value and validity of STT score using MEVF

Four patterns were set with the STT score cutoffs at two, three, four, and five. Participants were divided based on MEVF findings into the masticating group (n = 60), in which mastication movements were observed, and the non-masticating group (n = 13), in which only squeezing the test food or swallowing the test food whole without mastication were observed. Table 3 shows a cross-table of the two STT groups and the two MEVF groups, the results of Fisher’s exact test, and the Youden index for each STT score cutoff. A significant association with the two MEVF groups was found when STT score cutoffs were set at three (p = 0.019), four (p = 0.001), and five (p = 0.001).
3.5. Examination of cutoff value and validity of STT score using MEVF

The relationship between the two STT score groups and the two FILS groups was investigated for the three STT score cutoffs of 3, 4, and 5 with significant associations found between the two STT score groups and the two MEVF groups. Table 4 shows a cross-table of the two STT groups and the two FILS groups, and the results of Fisher’s exact test for each STT score cutoff. With participants classified according to the STT score into the STT score ≤2 group and the STT score ≥3/non-transport group, a significant association with the two FILS groups was found (p = 0.032).

| Table 3. Association of Sakiika transport test score and masticatory ability as classified by videofluoroscopy (VFSS). |
|---------------------------------------------------------------|
| Overall | STT score ≥2, Non-transporting | STT score =1 | STT score ≥3, Non-transporting | STT score ≥4, Non-transporting |
| MEVF | Non-masticating | Masticating | Non-masticating | Masticating | Non-masticating | Masticating |
| The number of participant’s Sakiika Transport Test (STT) | 73 | 13 | 60 |
| STT score ≥2, Non-transporting | 40 (55%) | 9 (69%) | 31 (52%) | 0.359 | 23% | 88% | 1.33 | 0.65 | 0.17 |
| STT score =1 | 33 (45%) | 4 (31%) | 29 (48%) |
| STT score ≥3, Non-transporting | 23 (32%) | 8 (62%) | 15 (25%) | 0.019 | 35% | 90% | 2.48 | 0.51 | 0.37 |
| STT score ≥4, Non-transporting | 50 (68%) | 5 (38%) | 45 (75%) |
| STT score ≥5, Non-transporting | 12 (16%) | 7 (54%) | 5 (8%) | 0.001 | 58% | 90% | 6.75 | 0.50 | 0.46 |
| STT score ≥4, Non-transporting | 61 (84%) | 6 (46%) | 55 (92%) |
| STT score ≥5, Non-transporting | 64 (88%) | 7 (54%) | 57 (95%) |

MEVF; Masticatory ability evaluation by VFSS, P; p-value for the fisher’s exact test, PPV; Positive predictive value, NPV; Negative predictive value, PLR; Positive Likelihood Ratio, NLR; Negative Likelihood Ratio

| Table 4. Association of Sakiika transport test score and food texture classified by FILS. |
|---------------------------------------------------------------|
| Overall | FILS | The odds ratio (95% confidence interval) | P |
| TMD without mastication | Food with mastication |
| The number of participant’s Sakiika Transport Test (STT) | 73 | 22 | 51 |
| STT score ≥3, Non-transporting | 23 (32%) | 11 (50%) | 12 (24%) | 3.25 (1.13-9.35) | 0.032 |
| STT score ≥4, Non-transporting | 50 (68%) | 11 (50%) | 39 (76%) | 1.00 (reference) |
| STT score ≥5, Non-transporting | 12 (16%) | 5 (23%) | 7 (14%) | 1.85 (0.52-6.63) | 0.492 |
| STT score ≥4, Non-transporting | 61 (84%) | 17 (77%) | 44 (86%) | 1.00 (reference) |
| STT score ≥5, Non-transporting | 9 (12%) | 5 (23%) | 4 (8%) | 3.46 (0.83-14.40) | 0.118 |
| STT score ≥4, Non-transporting | 64 (88%) | 17 (77%) | 47 (92%) | 1.00 (reference) |

FILS; Food Intake LEVEL Scale, TMD; Texture modified diet, P; p-value for the fisher’s exact test

3.5. Examination of cutoff value and validity of STT score using MEVF

The relationship between the two STT score groups and the two FILS groups was investigated for the three STT score cutoffs of 3, 4, and 5 with significant associations found between the two STT score groups and the two MEVF groups. Table 4 shows a cross-table of the two STT groups and the two FILS groups, and the results of Fisher’s exact test for each STT score cutoff. With participants classified according to the STT score into the STT score ≤2 group and the STT score ≥3/non-transport group, a significant association with the two FILS groups was found (p = 0.032).

4. Discussion

This study was a pilot study to develop a new oral function screening test focusing on jaw movement during stage I transport, which was observed when solid food requiring mastication was eaten [19]. The STT evaluated the number of vertical jaw movements while transporting the test food to the molars. For the safe ingestion of solid and liquid foods, it is necessary to evaluate perioral movement based on food texture. To evaluate mastication, food with a certain degree of firmness is required, rather than liquid or paste-type food that is quickly transported to the pharynx and swallowed after ingestion. Furthermore, considering the patient’s pharyngeal function and the possibility of accidental ingestion, the test food needs sufficient size and hardness to avoid being easily bitten off and swallowed. In this study, squid jerky sticks of approximately 100 mm in length were used as the test food. During the test, one end of the test stick was placed outside the oral cavity. Thus, it minimized the risk of accidental ingestion or aspiration during the mastication test in older people and people with dysphagia. Additionally, the examiner could observe tongue movements indirectly through the movement of the test stick extending from the subject’s lips. Squid jerky (sakiika in Japanese) is a traditional food in Japan, and its taste stimulates the patients’ appetite [30].

The STT could be easily performed on patients with cognitive decline, as the test procedure is simple. Previous oral assessments
such as the tongue pressure test, oral diadochokinesis measurement, bite force measurement, and masticatory performance test are sometimes complicated to perform in patients with cognitive decline. In particular, the procedure for masticatory performance tests using gummy jellies seemed complicated for the older adults with dysphagia who participated in the study.

The test method developed in this study should be feasible in other countries using foods with similar properties, such as beef jerky or dried fruit. Considering screening tests that should be fast, safe, and inexpensive [31], the STT meets these requirements.

The reliability, validity, sensitivity, and specificity of the STT were examined to assess the utility of the STT as a screening tool. The STT scores counted by the two examiners showed a high k coefficient, indicating that the STT offers good reliability.

The STT score cutoff was investigated as an effective screening tool for evaluating the tongue rotation and lateral movement required for mastication in patients with dysphagia. The validity of the STT was verified by comparing the STT scores and findings from MEVF.

The anteroposterior images of the VFSS as the gold standard in dysphagia evaluation [32] can show movements of a test food containing a contrast agent after injection on the midline of the anterior tongue with a spoon. It is then possible to assess whether the food is carried by the tongue to the molar region and chewed by the vertical movement of the teeth, whether it is only squeezed against the palate by the tongue surface, or whether it is transported to the pharynx in its original state (swallowed whole) [24]. With inadequate transport defined as an STT score of ≥3, ≥4, or ≥5, significant associations were found with the masticating and non-masticating groups as evaluated by MEVF. The actual swallowing function in many older individuals living at home or in facilities has been reported in the past without any testing being performed, and in many cases, resulted in discrepancies between feeding, swallowing function and nutritional intake [33]. We considered it necessary to establish a safe cutoff value for the STT score so that it could be used as an indicator for screening when modifying the food texture in such cases.

We considered that a safe cutoff value for the STT score should be set to allow screening with the STT as an indicator when modifying the texture of food for older individuals at home or in facilities. The STT was considered more sensitive when the participants with a high score or those evaluated as non-transporting in the STT occupied a high proportion of the participants found to be non-masticating by MEVF. In addition, the STT was considered safe when the participants evaluated by MEVF as non-masticating occupied a low proportion of the participants with a low score in the STT, meaning that the negative likelihood ratio was low. For this reason, an STT score of 3 was considered valid as the cutoff. In this instance, the STT had a sensitivity of 62% and a specificity of 75%. The negative predictive value was 90%. In other words, if the result was a negative STT, there were no significant issues with the tongue movements necessary for mastication.

The validity of the STT as a screening tool was examined by comparing the intake status of “foods that do not need to be masticated” to “foods that need to be masticated” in the FILS. In summary, the association between the STT score and the FILS food texture classification with or without mastication was investigated. When inadequate transport was defined as an STT score of ≥3 or non-transport, a significant association was demonstrated between the STT and the FILS food texture groups. These results indicate that an STT score cutoff of 3 was valid when examined in terms of both masticating and adjusting food texture.

One factor that limited the effect of this study was the small number of participants. We were unable to secure a sufficient number of patients because we excluded those with no molar occlusion or defective anterior teeth due to the requirements of the test. Consequently, the results may have been affected by a type II error. Future studies should be conducted with a larger number of participants.

The STT may also be useful for adjusting food texture. The STT is a screening test that can be performed simply using another type of food with the same texture as squid jerky. While other methods for screening mastication have existed in the past, the STT is a safe and easy method, and this study may be of considerable significance to clinical practice.

5. Conclusion

The STT is a screening test that assesses the ability to transport food to the molars for mastication, focusing on stage I transport. The STT score is determined by counting the number of vertical jaw movements in conjunction with the rotational and lateral tongue movements when transporting food to the molars. The STT score showed a high negative predictive value when compared to the masticatory performance assessed via the VFSS. This study suggested that the STT was useful in identifying individuals who could perform the tongue rotation and lateral movements required for mastication.

Conflicts of interest

The authors declare no conflict of interest.

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