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ORIGINAL ARTICLE

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Oral hypofunction in the older population: Position paper of the Japanese Society of Gerodontology in 2016

Shunsuke Minakuchi[1] | Kazuhiro Tsuga[2] | Kazunori Ikebe[3] | Takayuki Ueda[4] | Fumiyo Tamura[5] | Kan Nagao[6] | Junichi Furuya[7] | Koichiro Matsuo[8] | Ken Yamamoto[9] | Manabu Kanazawa[1] | Yutaka Watanabe[10] | Hirohiko Hirano[11] | Takeshi Kikutani[12] | Kaoru Sakurai[4]

[1]Gerodontology and Oral Rehabilitation, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan
[2]Department of Advanced Prosthodontics, Hiroshima University Institute of Biomedical and Health Sciences, Hiroshima, Japan
[3]Department of Prosthodontics, Gerodontology and Oral Rehabilitation, Osaka University Graduate School of Dentistry, Suita, Japan
[4]Department of Removable Prosthodontics & Gerodontology, Tokyo Dental College, Tokyo, Japan
[5]Tama Oral Rehabilitation Clinic, The Nippon Dental University, Tokyo, Japan
[6]Department of Oral & Maxillofacial Prosthodontics, Institute of Biomedical Sciences, Tokushima University Graduate School, Tokushima, Japan
[7]Department of Oral Health Sciences for Community Welfare, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan
[8]Department of Dentistry and Oral-Maxillofacial Surgery, School of Medicine, Fujita Health University, Toyoake, Japan
[9]Department of Community Dentistry, Tsurumi University School of Dental Medicine, Yokohama, Japan
[10]Research on Social and Human Sciences, Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan
[11]Dentistry and Oral Surgery, Tokyo Metropolitan Institute of Gerontology, Tokyo, Japan
[12]Division of Clinical Oral Rehabilitation, The Nippon Dental University Graduate School of Life Dentistry at Tokyo, Tokyo, Japan

Correspondence
Manabu Kanazawa, Gerodontology and Oral Rehabilitation, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, Japan.
Email: m.kanazawa.ore@tmd.ac.jp

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Background: There is growing international interest in identifying the effects of ageing on oral health and on appropriate strategies for managing oral disorders. The Japanese Society of Gerodontology (JSG), as the official representative of researchers and clinicians interested in geriatric dentistry in Japan, makes several recommendations on the concept of "oral hypofunction."

Aims: This study proposes diagnostic criteria and management strategies to reduce the risk of oral hypofunction among older people.

Conceptual Framework: We define oral hypofunction as a presentation of 7 oral signs or symptoms: oral uncleanness; oral dryness; decline in occlusal force; decline in motor function of tongue and lips; decline in tongue pressure; decline in chewing function; and decline in swallowing function. The criteria of each symptom were determined based on the data of previous studies, and oral hypofunction was diagnosed if the criteria for 3 or more signs or symptoms were met.

Conclusions: We recommend that more evidence should be gathered from clinical studies and trials to clarify our diagnostic criteria and management strategies.

KEYWORDS
older people, oral hypofunction

1 | BACKGROUND

The concept of health in older people and the structural relationships among many factors interfering with health have been discussed from various perspectives including medical, mental and social aspects. The mechanism and framework of how oral disorders are involved in general hypofunction, dysfunction and handicap have also been discussed.[1-7] It is thought that older adults enter a frail state in the process of losing independence. Sarcopenia and malnutrition are closely involved in the cycle of frailty, which contains many psychological factors and social factors.[8,9] For older adults whose sarcopenia has become obvious, the ability to eat and the appropriateness of foods to be ingested become increasingly important. Therefore, in order to prevent sarcopenia and frailty at an early stage, it is important to evaluate oral function.

In March 2014, the study group of the National Center for Geriatrics and Gerontology in Japan presented a pioneering concept of a progressive process of general functional decline via decreased oral function.[10] They showed that recovery can be expected by various interventions before becoming frailty. In the proposed conceptual diagram, decreased oral function is referred to as "oral frailty"; namely, "oral frailty" here means frailty that manifests only in the oral cavity with signs or symptoms specified as decreased articulation, slight choking or spillage while eating, and an increased number of unchewable foods. That is not disease and is a condition. Accordingly, to recover from oral frailty, it is important not only to maintain oral hygiene for preventing periodontitis and dental caries, but also to restore function by placing an appropriate prosthesis for tooth loss. Consequently, there is a growing awareness that the recovery and maintenance of oral function help delay the onset of conditions requiring nursing care, thereby helping to extend healthy life expectancy. However, neither the definition nor positioning of the key term "oral frailty" has been clarified to date.

The JSG proposed "oral hypofunction" as the stage at which recovery can be expected by performing dental treatment before oral dysfunction occurs. Then, we developed a hypothesis that oral frailty and oral hypofunction emerge during the process towards oral dysfunction among the various declines in ability. In addition, as a starting point for discussing this problem, we presented criteria for diagnosing oral hypofunction.

2 | POSITIONING OF ORAL HYPOFUNCTION

The process by which older people become dependent is gradual, and the state of oral health, dental treatment and prevention also change according to the stage. Pretty et al[11] formed a comprehensive framework for assessment, prevention, treatment and communication between interprofessional healthcare teams according to the level of dependency. Declines in oral function also progress stepwise with the decline of systemic function. In order to prevent oral function from becoming irreversible, it is necessary to clearly indicate the diagnostic method and diagnostic criteria for each stage. In this study, we focused on oral function and created a conceptual diagram divided into 4 stages: healthy state, oral frailty, oral hypofunction and oral dysfunction (Figure 1). The diagram illustrates that the stage of oral frailty and oral hypofunction can be restored to the previous stage by various remedies described in each level. The flow guides older adults, through education and awareness of oral frailty, towards programmes intended to prevent them from reaching a state where they require nursing care; those who are identified by the programmes as being at risk for oral hypofunction are advised to visit a dental clinic.

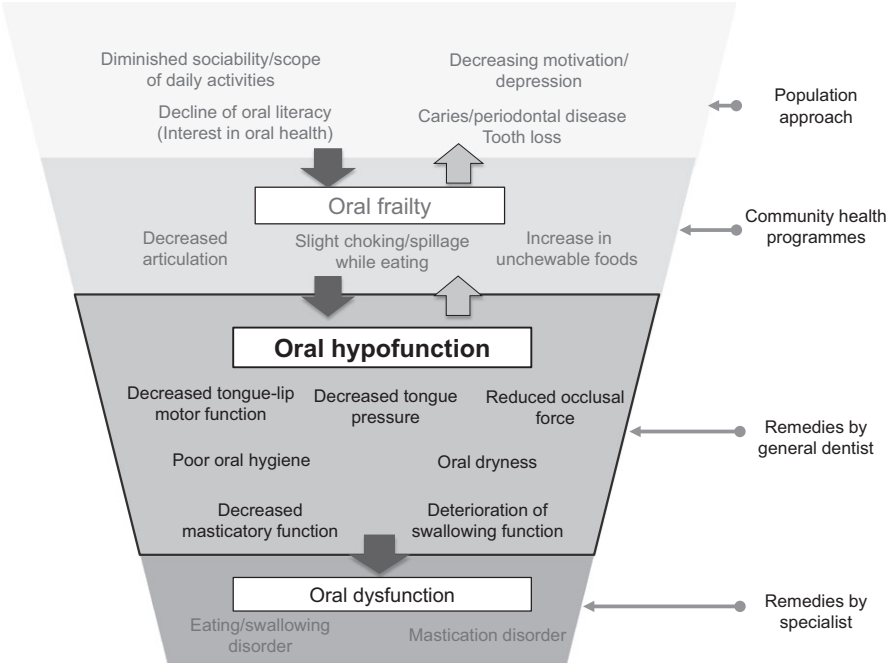

FIGURE 1 Oral hypofunction with age

Additionally, we selected 7 conditions (poor oral hygiene, oral dryness, reduced occlusal force, decreased tongue-lip motor function, decreased tongue pressure, decreased masticatory function, and deterioration of swallowing function) for making a diagnosis of oral hypofunction and established initial thresholds to be used as diagnostic criteria for these conditions (Table 1). Furthermore, based on the results of a study conducted at Fujita Health University Hospital,[12] we suggested that "oral hypofunction" be defined as the state when 3 or more of these diagnostic criteria are met. It is important that intervention and training can restore the state of oral hypofunction back to the state of oral frailty. If dental professionals provide appropriate intervention for patients with oral hypofunction, it will help them avoid developing oral dysfunction, thereby preventing frailty and from reaching the state of requiring long-term care.

3 | CONCEPT OF SIGNS AND SYMPTOMS CONSTITUTING ORAL HYPOFUNCTION AND DIAGNOSTIC CRITERIA

3.1 | Poor oral hygiene

3.1.1 | Concept and assessment

Poor oral hygiene means that the number of microorganisms in the mouth of older adults has abnormally increased.

The number of bacteria on the tongue dorsum is known to be correlated with that in saliva.[13] The number of microorganisms is measured on the tongue dorsum by rubbing a swab back and forth 3 times across a length of 1 cm over the central area of the tongue dorsum to obtain a sample and then using a bacterial counter (Panasonic Healthcare Co., Ltd.).[14,15]

As an alternative method, the degree of tongue coating is assessed by visual inspection using the Tongue Coating Index (TCI).[16] A diagnosis of poor oral hygiene is made when either of the following criteria is met:

(1). The total number of microorganisms (CFU/mL) is $10^{6.5}$ or more.
(2). TCI is 50% or higher.

TABLE 1 Measurements of clinical signs/symptoms of oral hypofunction

Clinical Signs	Measurements
Poor oral hygiene	The total number of microorganisms (CFU/mL) is $10^{6.5}$ or more.
Oral dryness	The measured value obtained by a recommended moisture checker is less than 27.0.
Reduced occlusal force	The occlusal force is less than 200 N.
Decreased tongue-lip motor function	The number of any counts of/pa/,/ta/or/ka/ produced per second is less than 6.
Decreased tongue pressure	The maximum tongue pressure is less than 30 kPa.
Decreased masticatory function	The glucose concentration obtained by chewing gelatin gummies is less than 100 mg/dL.
Deterioration of swallowing function	The total score of EAT-10 is 3 or higher.

3.1.2 | Background

Although outcome measures to assess poor oral hygiene in older adults have not been clarified, conceivable outcomes include aspiration pneumonia prevention,[14] postoperative pneumonia prevention and intraoral infection prevention. If we take these outcomes into consideration, a state that allows the number of salivary microorganisms to increase should be assessed. While there are various ways to count intraoral bacteria and various methods for evaluating the state of intraoral hygiene, no studies have reported thresholds for the outcome. Ideally, all causal factors should be evaluated, but considering the burden on patients as well as the manpower, time and cost of making such an evaluation, a simple and quick method is needed.

3.2 | Oral dryness

3.2.1 | Concept and assessment

Oral dryness refers to an abnormally dry state in the oral cavity or a subjective sign or symptom accompanying a feeling of intraoral dryness. As the pathophysiological condition involves a lack of moisture deriving chiefly from saliva, the functions contributing to homoeostasis of a living organism are lost, inducing various disorders.

An oral moisture checker (Mucus, Life Co., Ltd.) is used to measure mucosal wetness in the central area of the tongue dorsum. If no test devices are available, the Saxon test may be used instead as the participant may have difficulty in spitting. However, the amount of saliva absorbed in the Saxon test highly depends on the size of the gauze to be measured. Therefore, a gauze sponge (type 3 medical gauze, 7.5 cm square, 12-ply, dry weight 2 g) equivalent to the one used in the original Saxon test (Kerlix®, 12-ply, 10 × 10 cm, Kendall) should be used. Alternatively, a calibration value for the gauze being used needs to be calculated in advance.

A diagnosis of oral dryness in our assessment is made when either of the following criteria is met:

(1). The measured value obtained with the oral moisture checker is less than 27.0.
(2). The results of the Saxon test are 2 g/2 min or below.

* The gauze sponge used in the test must be of the correct size.

3.2.2 | Background

Oral dryness manifests as a prodromal symptom of an overall decrease in oral function, rather than a disease resulting from organic disorders. Therefore, it should not be underestimated as a sign of oral frailty.[17]

When evaluating these conditions, an oral moisture checker is suitable for quantitatively assessing the amount of moisture at the measuring site. The device has demonstrated that the amount of moisture in intraoral soft tissue is correlated with the amount of salivary secretion and has shown good results pertaining to sensitivity and specificity in screening for individuals with decreased salivary secretion.[18,19]

The Saxon test allows the tester to collect test samples even though the participant is expected to have difficulty in spitting as noted above, so we chose it as an alternative test method from various techniques for evaluating the amount of salivary secretion.[20,21]

3.3 | Reduced occlusal force

3.3.1 | Concept and assessment

Reduced occlusal force is a condition where the occlusal force with natural teeth or dentures is decreased. While strongly correlated with masticatory ability and influenced by the number of natural teeth and occlusal support, the condition is also affected by muscular weakness.[22]

(1) Test method

The occlusal force of the whole dentition is measured for 3 seconds of clenching in the intercuspal position using pressure indicating film.[23] For denture wearers, the measurement is performed with the dentures in place.

(2) Alternative test method

Although there are no alternative test methods for measuring occlusal force, we propose using the number of natural teeth as an alternative.

A diagnosis of reduced occlusal force is made when either of the following criteria is met:

- Occlusal force is less than 200 N.
- The number of natural teeth excluding remaining roots and teeth with mobility 3 is less than 20.

3.3.2 | Background

Low occlusal force has been reported to lead to decreased intake of vegetables, fruits, antioxidant vitamins and dietary fibre.[24] Although the number of teeth is also related to intake of these nutrients,[25-27] the association with occlusal force is considered to be stronger.[24]

It has also been reported that low occlusal force (less than 200 N) is frequently found not only in people with low weight but also in those with obesity.[28] Additionally, some studies have found that occlusal force is related to decline in motor function and falls.[22,29]

Many studies have shown that a smaller number of teeth lead to lower occlusal force and poorer masticatory ability.[30]

People with 20 or more natural teeth have been reported to be less susceptible to frailty than those with edentulous jaws.[31] It has been found in some longitudinal studies that those who have edentulous jaws[32,33] or few natural teeth[34] suffer a decline in cognitive function.

In summary, masticatory function is largely maintained if 20 or more natural teeth are present or occlusal force is 200 N or more. This is also relevant to the 8020 Campaign (Japan Dental Association) promoted in Japan and the concept of shortened dental arch.

3.4 | Decreased tongue-lip motor function

3.4.1 | Concept and assessment

Decreased tongue-lip motor function is a condition where speed and dexterity, which represent motor skills of the tongue and lips, are reduced as a result of a decline in brain function and perioral muscle function owing to systemic diseases and changes with ageing. Comprehensive measurements of motor speed and dexterity of the tongue and lips are taken as oral diadochokinesis. The participant is instructed to produce each of the syllables/pa/,/ta/and/ka/repeatedly for 5 seconds. The number of respective syllables produced per second is determined using an automatic counter (Kenkokun Handy, Takei Scientific Instruments Co., Ltd.)[35] or the pen dotting method.

A diagnosis of decreased tongue-lip motor function is made when the number of any of/pa/,/ta/or/ka/produced per second is less than 6.

3.4.2 | Background

The tongue and lips should move in a synchronised motion, with the mandible, cheeks, soft palate and throat playing an integral part in the crucial oral functions for daily life. Possible causes of decreased tongue-lip motor function include ageing, cerebrovascular disorder, neuromuscular diseases including Parkinson's disease, traumatic injury, late effects of head and neck surgery, muscle atrophy accompanying disuse syndrome, and malnutrition. In the assessment of motor functional decline in the tongue and lips, oral diadochokinesis measured by speed and dexterity when pronouncing/pa/,/ta/and/ka/is used. In general,/pa/,/ta/and/ka/are used to evaluate motor function, one for each of lip movement, anterior region of the tongue and posterior region of the tongue. If automatic measurement is not possible, an easy alternative is to use the pen dotting method wherein the tester marks a pen dot for each syllable as he/she hears the participant pronounce it. Although a variety of standard values have been reported for oral diadochokinetic rate, the mean values obtained in many studies conducted in community-dwelling older adults[36,37] have converged on 6-7 times for every syllable. Watanabe et al[38] carried out a large-scale study in 4720 older adults. The results

showed that, in a group of 766 healthy participants, the average oral diadochokinetic rates ranged from 5.6 to 6.3, while in a group of 535 participants with frailty, the average oral diadochokinetic rates ranged from 5.0 to 5.6. Additionally, in all groups, that is, healthy group, pre-frailty group and frailty group, the oral diadochokinetic rate decreased significantly with higher age stratum, and in all age strata, the oral diadochokinetic rate decreased as frailty progressed.

It is important to detect decreased tongue-lip motor function which precedes frailty. Accordingly, it is considered reasonable to define the occurrence of decreased tongue-lip motor function when the oral diadochokinetic rate for any of the syllables/pa/,/ta/and/ka/is less than 6.0. However, it should be noted that the value may change depending on the intraoral status such as ill-fitting dentures, mental status, nutritional status, experience of oral function training, experience of receiving oral health education and so on.

3.5 | Decreased tongue pressure

3.5.1 | Concept and assessment

Decreased tongue pressure refers to a condition where the pressure generated between the tongue and the palate and food is reduced owing to chronic functional decline in the group of muscles that move the tongue. As the condition progresses, normal mastication, bolus formation and swallowing are impaired, which may lead to insufficient food intake to meet the amount of nutrition required.

To test the tongue pressure, the maximum tongue pressure is measured using a tongue pressure measuring instrument (JMS tongue pressure measuring instrument TPM-01, JMS Co., Ltd.). The maximum tongue pressure determined by the instrument is the reading of the pressure exerted when the participant compresses a balloon attached to the tongue pressure probe onto the anterior palate for a few seconds using the maximum voluntary force of the tongue. The participant should be instructed to practice the procedure in advance. Measurements should be taken several times, allowing the participant to rest during every interval, and the mean value used for assessment. If the participant is wearing dentures and palatal augmentation prostheses, they should be worn during measurement, but only if used ordinarily.

A diagnosis of decreased tongue pressure is made when the maximum tongue pressure obtained by this test is less than 30 kPa.

3.5.2 | Background

The tongue performs complicated movements for mastication, swallowing, and speech in harmony with the lips, mandible, pharynx and larynx. Although these functions are crucial in maintaining life and QOL, their rapid and complicated movements remain to be studied. The value of tongue pressure measured with a prototype of this testing device was reported to be significantly correlated with the value measured with the Iowa Oral Performance Instrument (IOPI)[39]; therefore, the test can be used globally. Accordingly, the tongue pressure test is being used at present for epidemiological studies, general clinical settings and prevention of reaching the state requiring long-term care.

Conceivable causes of decreased tongue pressure include ageing,[40] cerebrovascular disorder,[41] neuromuscular diseases such as Parkinson's disease[42] and spinal and bulbar muscular atrophy[43]; direct causes include traumatic injury and late effects of surgery[44]; interactive causes include disuse syndrome and malnutrition or sarcopenia.[45]

Although decreased tongue pressure may resolve by treatment interventions[46] including appropriate exercise therapy and improvement of intraoral morphology by prostheses (eg a palatal augmentation prosthesis), some cases such as those caused by neurodegenerative diseases may be difficult to cure, which suggests a need for prompt detection and remedy.

The availability of simple tongue pressure testing has led to the findings that decreased tongue pressure is related to the occurrence of choking in older adults requiring long-term care[47]; older adults requiring long-term care are more likely to have decreased tongue pressure compared to healthy older adults[48]; and inability to take regular foods indicates a decrease in tongue pressure. We have set the cut-off value for decreased tongue pressure at 30 kPa because a study in 201 older adults who were hospitalised or residing in a welfare facility for seniors recently reported that, of 14 individuals who had a maximum tongue pressure of 30 kPa or higher and all on regular food, the number of those who shifted to universal design foods increased as their maximum tongue pressure decreased.[49]

3.6 | Decreased masticatory function

3.6.1 | Concept and assessment

As the health status and intraoral environments decline with ageing and/or disease, spillage while eating and choking when swallowing occur more frequently, and the number of unchewable foods increases over time, leading to loss of appetite and fewer foods that are eaten. Decreased masticatory function refers to a condition where these manifestations are aggravated and is defined as a condition where the occlusal force and motor ability of the tongue decline, resulting in a state that may lead to malnutrition and a decrease in metabolic rate.

Glucose concentration obtained from chewed gummy jelly is measured to assess masticatory function. The participant is asked to chew 2 g of gummy jelly, and then, the amount of eluted glucose is measured using a masticatory ability testing system (Gluco Sensor GS-II, GC Corporation).[50]

On the other hand, the degree of fracture in the chewed gummy jelly is evaluated by comparing with the visual reference material.[51] This method requires no special instruments.

3.6.2 | Background

(1) Method of measuring the glucose concentration obtained from chewed gummy jelly

Major reports that have been published using this method with gummy jelly include the following.

Unno et al[52] measured the masticatory ability by this method in 65 healthy participants in their 1920s and showed that the measured values of 102.5-186.8 mg/dL reflected the effect of the variation in masticatory path pattern. A multicentre study by Shiga et al[53] measured masticatory ability before and after prosthetic treatment and showed an increase from 102.9 mg/dL for pre-prosthetic treatment to 150.8 mg/dL for post-prosthetic treatment.

Thus, although the effect depends on age, prosthetic treatment or occlusal contact area, the measured values were approximately 100 mg/dL or more if the masticatory ability of the participant was normal.

(2) Method of comparing the degree of fracture with the visual reference material

Using this method, Kosaka et al[51] measured masticatory ability in 2276 participants and reported that the lower quartile of individuals classified as Eichner class C corresponded to a score of 2. From a clinical standpoint as well, patients' complaints of "cannot chew" increase as the degeneration progresses to Eichner class C, in which dentitions have no occlusal support in the molar zone. Thus, we established the diagnostic criterion for decreased masticatory function for this method as a score of 2 or less.

3.7 | Deterioration of swallowing function

3.7.1 | Concept and assessment

The concept of deterioration of swallowing function is a condition where a decline in eating/swallowing function owing to ageing has occurred and dysfunction is present as a stage before a marked disorder manifests. Deterioration of swallowing function is assessed by a self-administered questionnaire for swallowing screening (the 10-item Eating Assessment Tool [EAT-10].[54] The assessment criterion of the EAT-10 questionnaire is a total score of 3 or higher.

3.7.2 | Background

The EAT-10 developed by Belafsky et al[54] in 2008 consists of 10 questions. Each question is answered on a 5-point scale (0, no problem; 4, severe problem). A diagnosis of suspected dysphagia can be made if the total score is 3 or higher.[55] In an investigational study that administered the EAT-10 to 1000 community-dwelling independent older adults and 2000 beneficiaries of the long-term care insurance selected by randomised stratified sampling in Tokyo,[56] 24.1% of the former group and 53.8% of the latter group exhibited a score of 3 or higher. Additionally, a reliability and validity assessment of the EAT-10 has indicated that, in individuals who were able to respond to the EAT-10 and exhibited a score of 3 or higher, there was a high likelihood of observing eating/swallowing disorder that is causing a slight problem.[57] Therefore, we consider that the population at risk for dysphagia may be detected by setting the threshold at 3 or higher.

When assessed as having deterioration of swallowing function, the person needs to undergo swallowing screening (repetitive saliva swallowing test, modified water swallow test, and cervical auscultation) and, as necessary, a detailed examination (videofluorography [VF] and videoendoscopy [VE]). Then, if an apparent abnormality is observed in eating/swallowing function, a diagnosis of eating dysfunction, instead of deterioration of swallowing function, is made and special intervention is required.

4 | DIAGNOSTIC CRITERIA FOR ORAL HYPOFUNCTION

Oral hypofunction is not a morphological condition such as missing teeth or caries, but a functional pathophysiological condition, which consists of deteriorated several oral functions (Table 1). We applied these diagnostic criteria to hospitalised patients in an acute hospital whose data samples had been acquired in a previous study.[12] Five of the 7 measurement items (number of microorganisms, oral wetness, number of natural teeth, tongue pressure and tongue-lip motor function) were allocated 0 or 1 point by the diagnostic cut-off values. Then, the summed points were used as the oral hypofunction score. As we consider that oral hypofunction is one of the risk factors for malnutrition, we examined the relationship between oral hypofunction score and nutritional status in the hospitalised patients. The score of the Mini Nutritional Assessment (MNA) was used as the indicator for malnutrition. The mean MNA score was compared among the groups of respective total scores of oral function. The results showed that the mean MNA score was 12.5 ± 2.1 for the group with zero points, but the score declined to 9.8-9.1 in the group with 1-3 points. In the group with 4 points, the mean MNA score significantly declined to 7.9 ± 3.2.

These results show that oral hypofunction and malnutrition are closely related. The group with 4 points showed a tendency of significant malnutrition. Oral hypofunction is regarded as the precursor of oral dysfunction, hence a score of 3 points or higher is likely to be an appropriate diagnostic criterion for oral hypofunction. Thus, we propose that oral hypofunction be defined as the state when more than 3 of the 7 oral function measures meet the diagnostic criteria.

5 | FUTURE CHALLENGES REGARDING ORAL HYPOFUNCTION

There are overlapping concepts within the 7 criteria which confound the key points within this conceptual model. For example, decreased tongue-lip motor function, decreased tongue pressure and decreased masticatory function, all overlap in both concept and principle. Further researches which are about neuromuscular condition influencing all of these criteria might be required. The diagnostic criteria for oral hypofunction were determined based on a broad range of reported literature. In the future, the prognosis of oral hypofunction or the effects of treatments on oral hypofunction should be clarified by further studies

on oral hypofunction. As Japan has one of the world's most rapidly ageing populations, the JSG has a duty to promote such studies.

CONFLICT OF INTEREST

With respect to the present paper, no companies or organisations have competing interests that should be disclosed.

ORCID

Takayuki Ueda http://orcid.org/0000-0002-6432-1749
Junichi Furuya http://orcid.org/0000-0002-8018-4537
Koichiro Matsuo http://orcid.org/0000-0002-4778-1954
Manabu Kanazawa http://orcid.org/0000-0003-2587-5455

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