Foodstuff

↓

Heating

↓ ←———— Enzyme solution

Impregnation

↓ ←———— Seasoning solution

Seasoning/arrangement/enzyme reaction

↓

Completion of enzyme reaction/heating for sterilization

↓

Rapid freezing

↓

Product

Fig. 1. Manufacturing process of the study diet (outline).

Methods

Study diet

Method for manufacturing the study diet

Figure 1 shows the outline for the manufacturing process of "iEat®" (EN Otsuka Pharmaceutical Co. Ltd.; study diet). Different methods were used for vegetable foodstuffs, such as vegetables and legumes, and animal foodstuffs, such as meat and fish. The technique used for softening the study diet is called enzyme homogeneous permeation, and is illustrated in Figure 2.

Evaluation of appearance and measurement of hardness

Figure 3 shows the appearances of a blender diet (modified traditional diet) and the study diet. The study diet retained similar appearances and colors to ordinary foods cooked by typical methods, and the foods were barely distinguishable in appearance, whereas the blender diet showed a tremendous change in appearance.

Table 1 lists the hardness values of the components of Chikuzenni (simmered chicken and vegetables), a study diet meal, compared with those of typically prepared components. The difference in hardness ranged by 12-fold between carrots, which were the softest, and bamboo shoots, which were the hardest. On the contrary, all of the components were of similar softness in the study diet. The physical property of hardness was measured by a creep meter (RE2-33005B; Yamaden) in accordance with the test method provided in the criteria for foods for mastication disorder (2009) [11].

Nutrients of the study diet

Table 2 lists the nutrients contained in each study diet menu. The nutrients were calculated based on the fifth revised and enlarged version of the Standard Tables of Food Composition in Japan [12].

Method of warming meals before serving

The study diet consisting of rice, main dishes, and side dishes was stored frozen and subsequently thawed/heated at 80°C for 30 min in a steam convection oven or steam microwave oven.

Participants

The study participants were Japanese inpatients under nutritional management for mastication difficulty or residents of nursing care facilities whose energy requirement was evaluated at 1200 kcal to 1500 kcal, but for whom the actual mean consumption rate of a modified traditional diet was approximately ≤75%, although the required amount was served. Consumption may or may not have been assisted.

Survey method

A multicenter joint group comparison study was performed to compare the modified traditional diet and the study diet. The study sites and investigators are listed in Table 3.

Breakfast, lunch, and dinner were served during the study period of 7 consecutive days. The subjects were served the modified traditional diet on days 1 and 2, the study diet on days 3, 4, and 5, and the modified traditional diet on days 6 and 7. The consumption rate was calculated for each meal by the weight differential method at breakfast, lunch, and dinner during the study period. The amounts of intake of energy, protein, lipids, carbohydrate, and sodium were calculated based on the consumption rate. The questionnaire was given after each meal during the study period. The questionnaire for health care professionals was completed by the health care professionals after observing the consumption state of the subject. Diarrhea, abdominal distension, nausea, vomiting, and abdominal pain were investigated as digestive symptoms.

Before implementation of the survey, the appropriateness of the conduct was reviewed by the institutional review board of each facility and approved. Written informed consent was obtained from each patient or a proxy consenter.

Evaluation items

The evaluation items were the consumption rate and amounts of intake of energy, protein, lipids, carbohydrate, and sodium, as well as the satisfaction level evaluated by the responses to the questionnaires provided by the participants and their health care professionals.

Evaluation method

For the consumption rate and dietary nutrition intake, the mean scores for 3 d of study diet ingestion and 4 d of modified traditional diet ingestion and the
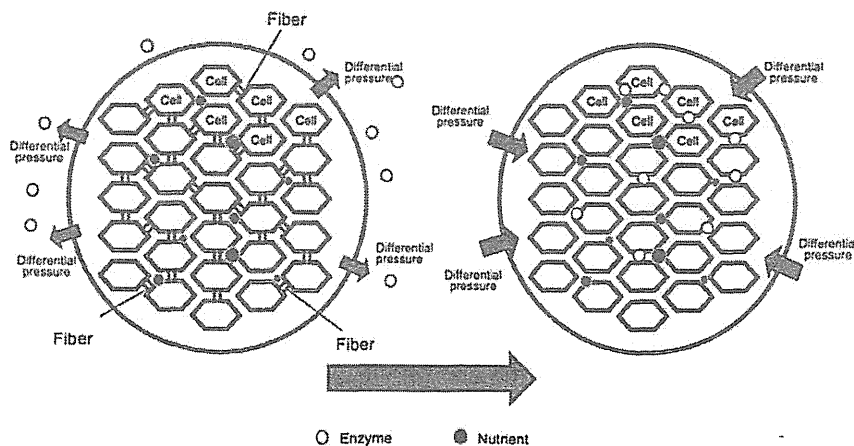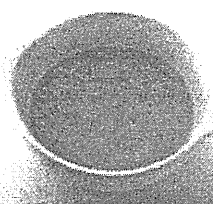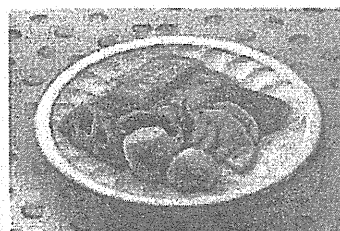

Fig. 2. Enzyme homogeneous permeation.

Menu:
Chikuzenni

Blender diet   Study diet

Fig. 3. Comparison of the appearances of the blender diet and the study diet.

daily results were compared. The results of the questionnaires were evaluated by six-stage grading and the mean values were calculated. The means of three meals during the 3-d study diet period and the 4-d modified traditional diet period were compared.

Statistical analysis

The per-protocol population was the major analysis population. A paired *t* test was performed for the consumption rate and amounts of intake of energy, protein, lipids, carbohydrate, and sodium between the modified traditional diet and the study diet (level of significance, $P < 0.05$; two-sided). Wilcoxon's signed rank-sum test was performed for the results of the questionnaires (level of significance, $P < 0.05$; two-sided).

Results

Handling of cases

Of the 72 participants registered, 57 were included in the final analysis after excluding 1 participant for violation of a served meal, 8 participants who dropped out, and 6 participants who had disease-induced fever or poor oral ingestion associated with anticancer agents.

Patient demographic factors

Table 4 shows the demographic factors of the 57 participants included in the study. Body mass index (BMI) was within the standard range, but close to the lower limit at 18.5 kg/m². The relatively low BMI was considered to reflect the nutrition state of the participants who were served meals for patients with impaired mastication, for which the consumption rate was <75%. The demographic data revealed that the underlying diseases of the participants were varied, and that meals for patients with impaired mastication were served to patients with various underlying diseases, rather than to patients with specific disease types. There were no established names for the meals served at the facilities, and various names were used at each facility (Table 5).

Table 1
Comparison of the hardness values of the study diet and a common meal

Menu	Ingredient	Hardness* (×104 N/m²)	
		Common meal	iEat
Chikuzenni	Carrot	9.1 ± 1.3	0.4 ± 0.2
	Chicken breast	69.0 ± 1.6	1.2 ± 0.3
	Bamboo shoot	107.5 ± 17.0	0.2 ± 0.0
	Burdock	39.1 ± 5.4	0.3 ± 0.1
	Lotus root	80.5 ± 9.0	1.0 ± 0.1

* The hardness was measured at 45°C, as the presumed heating temperature before eating.

Consumption rate

Tabulation and analyses were performed for 55 participants after excluding 2 additional participants who were served a modified traditional diet of porridge or thick porridge during the study diet period instead of the study diet rice (iEat® rice).

No significant differences were observed between the study diet and the modified traditional diet for both the mean consumption rates and daily consumption rates (Fig. 4).

Dietary nutrition intake

Tabulation and analyses were performed for 54 participants after excluding another participant for whom information on nutrients of the modified traditional diet was unknown.

The mean energy intake (EI) and mean protein intake were significantly higher during the 3-d study diet period than during the 4-d modified traditional diet period. In a comparison of day 2 and day 3, when the modified traditional diet was switched to the study diet, the amounts of EI, protein and lipid intake were significantly higher on day 3. On the contrary, in a comparison of day 5 and day 6, when the study diet was switched back to the modified traditional diet, the amount of intake of protein was significantly higher on day 5 (Table 6).

Questionnaire

The mean satisfaction levels during the total ingestion period of the study diet and modified traditional diet were evaluated by the participants and their health care professionals. The study diet had significantly higher scores than the modified traditional diet for "appearance" when evaluated by the participants, and for "joy of eating" and "overall satisfaction level" when evaluated by the health care professionals (Fig. 5). No significant difference was observed between the modified traditional diet and the study diet for ease of meal assistance when evaluated by the health care professionals for 38 participants who required total or partial assistance with consumption.

Gastrointestinal symptoms

Six occurrences of gastrointestinal (GI) symptoms (two of abdominal pain, one of vomiting, two of nausea, and one of abdominal distension) were reported in four participants, but all of these occurrences were judged to be unrelated to the study diet.

Table 2
Nutrients of the study diet

Menu			Weight (g)	Calories (kcal)	Protein (g)	Lipids (g)	Carbohydrate (g)	Sodium (mg)
Day 3	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Broiled salmon	62	122	11.8	7.7	0.2	122
		Chikuzenni	156	85	6.5	0.3	13.1	479
		Breakfast total	401	407	21.4	8.7	58.7	639
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Chicken teriyaki	86	89	10.7	1.7	7.2	235
		Creamed pork and beans	115	123	11.3	5.5	7.1	252
		Lunch total	384	412	25.1	8.0	59.7	525
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Braised sablefish	77	151	8.1	10.5	4.6	255
		Pot-au-feu	155	110	4.5	8.0	5.6	624
		Apple	102	91	0.0	0.0	22.9	24
		Dinner total	517	552	15.7	19.2	78.5	941
	Total		1302	1371	62.2	35.9	196.9	2105
Day 4	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Yellowtail teriyaki	90	164	10.4	8.0	10.9	292
		Nikujaga	166	119	5.8	2.6	17.9	393
		Breakfast total	439	483	19.3	11.3	74.2	723
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Marinated pork	93	112	10.4	4.8	5.6	235
		Braised pumpkin and beans	91	102	12.3	2.7	6.5	239
		Lunch total	367	413	25.8	8.1	57.4	512
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Sukiyaki	17	120	7.1	3.8	13.2	456
		Pan-fried red fish with oyster sauce	77	76	10.4	2.4	2.5	272
		White peach	102	103	0.3	0.0	25.9	30
		Dinner total	538	499	20.9	6.9	87.0	796
	Total		1343	1395	66.0	26.3	218.7	2031
Day 5	Breakfast	Rice	183	200	3.1	0.7	45.4	38
		Pan-fried shrimp and scallops with vegetables	100	61	10.8	0.5	3.2	287
		Grilled mackerel	62	196	10.3	16.1	0.2	153
		Breakfast total	344	457	24.2	17.3	48.8	478
	Lunch	Rice	183	200	3.1	0.7	45.4	38
		Beef stir-fried with black pepper	101	118	10.8	6.0	4.5	310
		Chinese-style boiled vegetables	131	61	4.5	0.8	10.0	299
		Lunch total	415	379	18.4	7.5	59.9	647
	Dinner	Rice	183	200	3.1	0.7	45.4	38
		Chicken curry	110	91	10.9	1.2	8.7	249
		Scallops and cauliflower in sticky sauce	170	67	7.3	0.5	9.0	548
		Mango	115	135	0.3	0.0	33.6	29
		Dinner total	578	493	21.6	2.4	96.7	864
	Total		1337	1329	64.1	27.1	205.4	1989

Table 3
Study sites and investigators

Study site	Investigator
Sapporo Minami Seishu Hospital	Nobuhisa Nakajima
General Rehabilitation Mihono Hospital	Hirofumi Nishiyama
Minamiyamato Hospital	Shin Fujii
Hokuto City Koyo Hospital	Hajime Nakase
Kanazawa Nishi Hospital	Tsutomu Kikuchi
Hirano General Hospital	Makoto Shimazaki
Chita City Hospital	Naoharu Mori
Fujita Health University Nanakuri Sanatorium	Akihiro Ito
Owase General Hospital	Hiroyuki Kato
Tsu Seikyo Hospital	Tomonori Miyazaki
Japanese Red Cross Kyoto Daiichi Hospital	Fumiko Oshima
Wakakusa Daiichi Hospital	Hideharu Yamanaka
Wakakusa Tatsuma Rehabilitation Hospital	Masataka Itoda
Kaneda Hospital	Takuji Mimura
Sunami Shusaikai Hospital	Yukitsugu Arimoto
Shinbeppu Hospital	Nobuyuki Kikuchi
Kumamoto Daiichi Hospital	Tetsushi Nogami

Discussion

Study diet: iEat®

Either minced diets or blender diets usually are served to patients having difficulty with mastication because of aging or disease, to suit the individual conditions. Yamashita et al. [13] pointed out that the amounts of nutrients supplied in minced and blender diets were reduced by the cooking process, because of the addition of water to soften the food or removal of components that were difficult to eat. Other problems considered to be inherent with blender diets and minced diets are that the addition of water and process of mincing increases the portion size and prevents sufficient nutritional intake, respectively, resulting in an undernutrition state. It is also a problem that the appearance of foods cannot be retained after softening by these methods [14]. In Japan, attempts have been made to solve the problem of appearance by adding a thickener to blender diets to reconstitute to the original appearance of the ingredients, but this requires a human touch. Techniques for softening foods by

Table 4
Demographic factors

	n	%
Sex		
M	23	40.4
F	34	59.6
Meal assistance		
None	34	59.6
Total	17	29.8
Partial	6	10.5
Dentures		
Yes	30	52.6
No	27	47.4

	Mean	SD
Age (y)		
M	78.5	±8.8
F	83.7	±9.0
Total	81.6	±9.3
Height (cm)		
M	158.9	±6.9
F	143.6	±8.0
Total	149.8	±10.6
Weight (kg)		
M	47.8	±9.2
F	38.7	±7.8
Total	42.3	±9.4
BMI		
M	19.0	±3.6
F	18.7	±3.3
Total	18.8	±3.4
BEE		
M	988.0	±172.4
F	899.0	±105.3
Total	934.9	±140.7

Underlying disease	n	%
Stroke (including sequelae)	19	33.3
Cancer/malignant neoplasm (including postsurgery)	9	15.8
Heart failure/heart disease	7	12.3
Fracture	5	8.8
Dehydration	4	7.0
Pressure ulcers	3	5.3
Pneumonia	2	3.5
Anemia	2	3.5
COPD	2	3.5
Dementia	2	3.5
Diabetes	1	1.8
Parkinson's disease	1	1.8
Other	17	29.8
None	2	3.5

BEE, basal energy expenditure; BMI, body mass index; COPD, chronic obstructive pulmonary disease

Table 5
Types of main and side dishes

Type of main dish	n	%
Porridge	40	70.2
Soft rice	10	17.5
Rice	2	3.5
Thickened porridge	2	3.5
Blender porridge	2	3.5
Gelled porridge	1	1.8
Total	57	100

Type of side dish	n	%
Minced diet	32	56.1
Blender diet	6	10.5
Bite-sized food	6	10.5
S-1 diet*	5	8.8
Soft food	3	5.3
Soft dish	3	5.3
Pressure-cooked diet or food	1	1.8
Stewed food	1	1.8
Total	57	100

* S-1 diet is an intermediate between a blender diet and a very finely minced diet, comprising a meal of a very finely minced diet in thick sauce.

traditional diet, and the study diet was an efficient diet rich in nutrients in a smaller quantity of food. Olin et al. [18] also reported that serving a high-density meal is more cost-effective for improving spontaneous EI by the elderly, and the study diet evaluated here would be positioned as a meal with such characteristics.

Consumption rate

No significant difference in the consumption rates was observed between the study diet and the modified traditional diet in this study. Few reports have been published about the effects of the appearance of a meal on the amount of food intake. Listed as factors related to food intake are tastiness of a meal, number of people present, food accessibility, eating locations, food color, ambient temperature and lighting, temperature of food, smell of food, time of consumption, and ambient sounds [19]. The relationships among the people sharing a meal are especially important, and it is generally reported that the amount of dietary intake is increased when more people are present. A mealtime becomes more relaxed and longer when eating with family or friends than when eating with strangers, which consequently results in increased amounts of dietary intake [19]. Li et al. also reported that age, sex, educational attainment, community, activity level, marital status, and drinking were significantly associated with fruit and vegetable consumption [20]. The results of the present study suggest that not only the appearance of food, but also other ambient factors, should be improved to increase the consumption rate. Lifestyle factors may need to be considered when dietary pattern is evaluated [21].

Although it is widely known that the results for consumption rates differ considerably depending on the survey methods used [22], the weight differential method used in the present study is considered to be the most accurate among the various methods [3,23].

Dietary nutrition intake

In addition to the intake of an appropriate amount of energy, intake of an appropriate amount of protein is

infusing hydrolytic enzymes, such as proteases and cellulases, recently have been reported [15,16]. These techniques make it possible to serve softened foods without changing the original appearances, which cannot be achieved using ordinary cooking methods.

The study diet evaluated here was developed using an enzyme-infusion method [17] that evenly infuses the enzyme within the ingredients to adjust the entire meal to a homogeneous softness. Because the study diet does not require the addition of water for softening, the nutrients are not diluted and the serving portion is not increased. As shown in Figure 3, the mean weight of food intake for the study diet was lower than that for the modified traditional diet. However, the study diet showed significantly higher levels of mean EI and protein intake than the modified traditional diet. The dietary nutrition intake per weight was higher for the study diet than for the modified
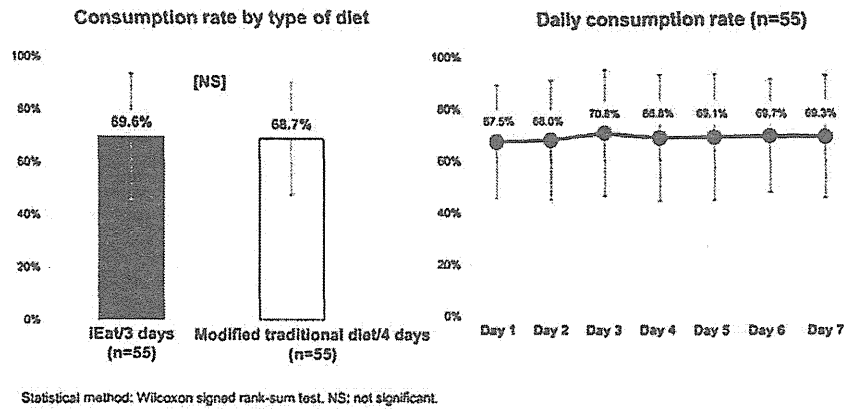
Fig. 4. Results of the consumption rate survey. Days 1, 2, 6, and 7: modified traditional diet; days 3–5: study diet.

indispensable for improvement and maintenance of the nutritional condition, and the requirement does not decrease in the elderly [24]. As reported previously, the mean EI and protein intake were significantly higher for the study diet than for the modified traditional diet. The significantly lower weight of food intake with the study diet compared with the modified traditional diet means a higher dietary nutrition intake per weight for the study diet compared with the modified traditional diet. Tanaka et al. [25] reported that the amount of protein intake from meat becomes lower with aging, and that a reduction in the intake of meat with favorable digestibility was the cause of lowered serum albumin. In the study diet, the foods are made sufficiently soft to be mashed by the tongue, even for meats that are difficult to soften by ordinary cooking methods, and this physical property would be one of the factors for the significantly higher level of protein intake in this study. The present results for the study diet suggest the possibility of improving the decreased protein intake associated with aging.

Survey of satisfaction level

With respect to the satisfaction level evaluated by the participants, the study diet scored significantly higher than the modified traditional diet for "appearance" based on the mean scores of the modified traditional diet (4 d) and the study diet (3 d). The effect of a difference in the appearance of a meal on the satisfaction level was evaluated by the participants. "Eating" is important for the elderly in terms of joy and purpose, and mealtimes were reported to be the number one joy for elderly people admitted (institutionalized) to nursing care facilities [26]. The joy of meals is expected to be enhanced by giving thought to the appearance of the meals.

Based on the evaluation by the health care professionals, the mean scores of "joy of eating" and "overall satisfaction level" were significantly higher for the study diet than for the modified traditional diet. It was shown that a change in the appearance of a meal influenced the joy of eating and the satisfaction level of the participants as evaluated by the health care professionals.

Table 6
Intake of nutrients

Consumption rate by type of diet: weight of ingested diet/amount of nutrients ingested					
	iEat (3 d)			Modified traditional diet (4 d)	
	Mean		± SD	Mean	± SD
Energy (kcal)	[*]	1097.2	±395.0	1036.4	±349.3
Protein (g)	[**]	49.9	±18.1	40.0	±14.1
Lipids (g)	[NS]	25.2	±9.8	25.3	±10.8
Carbohydrate (g)	[NS]	166.7	±61.6	161.4	±54.9
Sodium (mg)	[NS]	2302.4	±873.9	2261.8	±989.5
Total weight (g)	[**]	1099.2	±406.8	1222.7	±420.6

Daily consumption rate: weight of ingested diet/amount of nutrients ingested								
	Modified traditional diet		iEat				Modified traditional diet	
	Day 1	Day 2	Day 3		Day 4	Day 5		Day 6	Day 7
Energy (kcal)	1032.0	1032.2	[**]	1128.0	1104.6	[NS]	1059.1	1032.3	1049.3
Protein (g)	39.2	40.6	[**]	49.8	50.6	[**]	49.3	39.6	40.8
Lipids (g)	23.7	25.5	[**]	30.0	22.7	[NS]	22.9	25.3	26.6
Carbohydrate (g)	168.1	156.4	[NS]	163.9	172.3	[NS]	163.8	163.9	157.2
Sodium (mg)	2315.7	2214.3	[NS]	2338.0	2353.4	[NS]	2215.8	2218.6	2298.5
Total weight (g)	1207.2	1208.1	[**]	1092.5	1114.3	[**]	1090.7	1269.4	1209.7

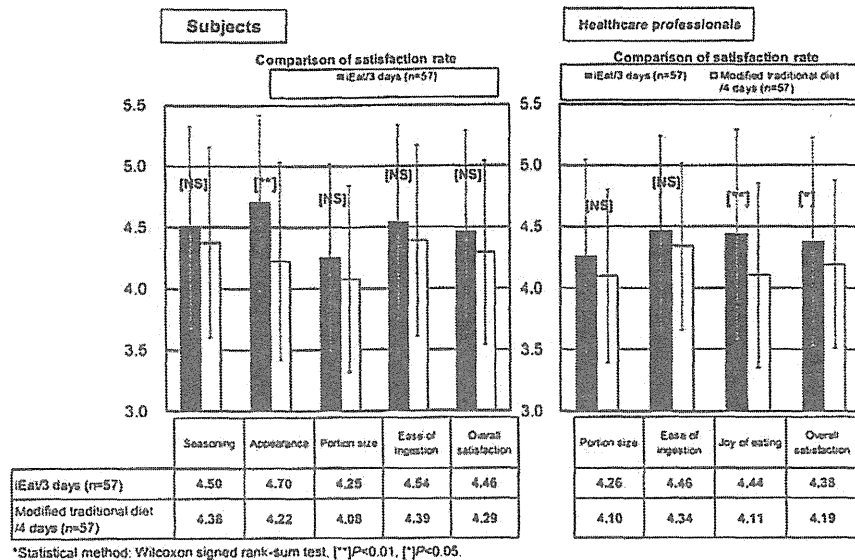Statistical method: t test. [**] P < 0.01, [*] P < 0.05.

Fig. 5. Comparison of satisfaction rates based on the questionnaire.

These findings clarified the significance of meals for not only supplementing nutrients, but also satisfying the participants.

Conclusions

The present results suggest that the study diet may have potential to replace modified traditional meals, such as minced diets and blender diets, for patients with impaired mastication, because it improved the satisfaction level for meals of patients who cannot eat ordinary meals, and increased EI and protein intake.

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ORIGINAL ARTICLE: EPIDEMIOLOGY,
CLINICAL PRACTICE AND HEALTH

Relationship between nutrition status and dental occlusion in community-dwelling frail elderly people

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Aim: This study aimed to determine the risk of malnutrition in some communities where the frail elderly receive public long-term care insurance. We also clarified the dental problems in those at risk of malnutrition.

Methods: A total of 716 frail elderly who lived in eight cities in Japan (240 males and 476 females with a mean age of 83.2 ± 8.6 years) were divided into three groups according to Mini Nutritional Assessment short form results: well nourished, at risk of malnutrition and malnourished. They were also divided into three groups in terms of remaining teeth occlusion and denture occlusion: group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; and group C, functionally inadequate occlusion with no dentures. The relationship between nutrition status and dental occlusion was evaluated using logistic regression analysis with sex, age, activities of daily living and cognitive function as covariates.

Results: The number of participants in each of the groups was as follows: 251 well nourished, 370 at risk of malnutrition and 95 malnourished. When they were divided into just two groups, (i) well nourished and (ii) at risk of malnutrition plus malnourished, in order to study malnutrition risk factors, there were significant relationships between their nutritious status and sex, Barthel index, and occlusion.

Conclusion: This large-scale cross-sectional survey showed that loss of natural teeth occlusion was a risk factor for malnutrition among community-dwelling frail elderly. Geriatr Gerontol Int 2013; 13: 50–54.

Keywords: frail elderly people, Mini Nutritional Assessment short form, nutrition, occlusion.

Introduction

The intake of nutrients from daily meals is the foundation of life. Low nutrition decreases the immunological defenses, reduces physical functions, and can be a direct or indirect cause of morbidity and mortality among the elderly.[1,2] It has been reported that 1–15% of outpatients and 15–60% of the institutionalized elderly suffer from protein-energy malnutrition (PEM),[3] suggesting that the condition of elderly at risk of malnutrition should be investigated and improved without delay.

Several screening methods are available for determining malnutrition, but the use of a questionnaire is a simpler and more convenient method for a large-scale survey.[4] Especially, The Mini Nutritional Assessment short form (MNA-SF) has been highly utilized worldwide, and its sensitivity and specificity have already been shown.[5,6]

The present study evaluated the malnutrition risk for community-dwelling frail elderly receiving public long-term homecare insurance in Japan using the MNA-SF to determine whether dental occlusion might influence the risk of malnutrition.

Methods

The participants were 716 elderly individuals living at home and receiving public long-term care insurance services (240 males and 476 females with a mean age of

83.2 ± 8.6 years) in eight prefectures in Japan (Tokyo, Fukushima, Kanagawa, Yamanashi, Shizuoka, Niigata, Fukuoka and Okinawa). Their malnutrition risk was evaluated using the MNA-SF, and also age, sex and underlying medical problems using the Charlson index[7] were determined. In addition, activities of daily living (ADL) and cognitive function were evaluated using the Barthel index[8] and the Clinical Dementia Rating,[9] respectively, based on information from caregivers or care managers. This evaluation also determined one of the living environment factors, whether or not living alone.

The participants received oral examinations by a dentist or dental hygienist at home or at the day care facility they usually used, and molar occlusion was classified into the following three groups according to edentulous condition and denture-wearing status:

- Group A, natural dentition with adequate function
- Group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws
- Group C, functionally inadequate occlusion with no dentures

Swallowing function was evaluated using a stethoscope to determine whether cervical auscultation of swallowing sounds was normal or abnormal.[10] Before the examination, the dentist and dental hygienist in charge were instructed about the cervical auscultation method.

The participants were divided into three groups according to the result of the MNA-SF: (i) well-nourished; (ii) at risk of malnutrition; and (iii) malnourished. The relationship between participants' general condition and oral status was analyzed using the χ^2-test and one-way ANOVA. In addition, participants were also divided into two groups: (i) well-nourished; and (ii) at risk of malnutrition or malnourished. Logistic regression analysis was carried out to study the significant risk factors influencing malnutrition. Participants were also divided into two groups according to whether they were:

(i) well-nourished *plus* those at risk of malnutrition; and (ii) malnourished. Logistic regression analysis was carried out to clarify the characteristics of malnourished subjects. PASW Statistics 18 (IBM, Tokyo, Japan) was used for statistical analysis with the significance level set at 95%.

Results

The MNA-SF showed the following: 251 individuals (94 males and 157 females) were well nourished, 370 (120 males and 250 females) were at risk of malnutrition and 95 (26 males and 69 females) were malnourished. Table 1 shows the general condition of participants, number of missing teeth and number of remaining teeth roots among those without occlusion according to nutrition group. The number of participants who lived alone by nutrition group was 30 in the well-nourished group (17.9%), 29 in the at risk of malnutrition group (14.0%) and 16 in the malnourished group (28.6%; $P < 0.05$).

The number of participants by occlusal relationship was 174 in group A (80 males and 94 females with a mean age of 78.7 ± 9.0 years), 421 in group B (120 males and 301 females with a mean age of 84.6 ± 8.0 years) and 121 in group C (40 males and 81 females with a mean age of 84.9 ± 7.7 years), which indicated that there was a significant correlation between occlusal relationship and nutrition status ($P < 0.05$; Fig. 1).

Cervical auscultation showed that the 516 participants exhibited normal swallowing sounds (151 males and 365 females with a mean age of 82.8 ± 8.4 years) and 200 had abnormal swallowing sounds (89 males and 111 females with a mean age of 84.0 ± 9.0 years). There was a significant relationship between normal swallowing sounds and nutrition status ($P < 0.05$, Fig. 2).

The results of the logistic regression analysis showed a significant relationship between malnutrition risk and sex, Barthel index, and occlusal relationship (Table 2).

Table 1 General condition and the number of missing teeth by nutrition group

	Well nourished	At risk of malnutrition	Malnourished
Age	81.9 ± 8.6	83.9 ± 8.3*	83.8 ± 9.3
Charlson index	1.4 ± 1.5	1.6 ± 1.4	1.8 ± 1.4**
Barthel index	77.1 ± 20.8	57.2 ± 27.8*	34.3 ± 28.6*,**,***
Clinical dementia rating	0.8 ± 0.9	1.2 ± 1.0*	1.4 ± 1.1**
No. missing teeth	20.2 ± 10.6	22.4 ± 9.8*	21.2 ± 9.6
No. remaining teeth root	0.9 ± 2.2	1.7 ± 3.3*	2.3 ± 4.0**
No. occlusal group (group A/B/C)	80/145/26	66/232/72	28/44/23†
No. swallowing sounds (normal/abnormal)	208/43	262/108	46/49†

One-way ANOVA and Games-Howell pairwise comparison test were used for parametric variables. *$P < 0.05$, well-nourished versus at risk of malnutrition; **$P < 0.05$, well nourished versus malnourished; ***$P < 0.05$, at risk of malnutrition versus malnourished. †The χ^2-test was used for non-parametric variables (<0.05).

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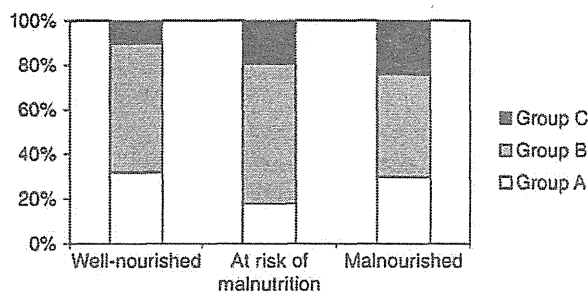Figure 1 Relationship between nutrition and occlusion (χ^2-test, $P < 0.05$). Group A: natural dentition with adequate function. Group B: partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws. Group C: functionally inadequate occlusion with no dentures.
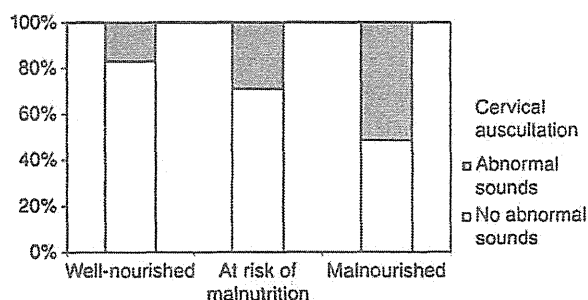

Figure 2 Relationship between nutrition and abnormal swallowing sounds detected by cervical auscultation (χ^2-test, $P < 0.05$).

A significant relationship was also observed between malnutrition and Barthel index, abnormal swallowing sounds by cervical auscultation, and living alone (Table 3).

Discussion

The results of the present study showed that the number of frail elderly with malnutrition was 13.3% (95), which is nearly in agreement with the results of a previous study carried out in Japan.[11] Furthermore, the number of the participants at risk of malnutrition, including those in the at risk of malnutrition and malnourished groups was 64.9% (465), which surprisingly exceeded 50% of the participants. This result shows that improvement in the nutrition status of frail elderly living in home care needs to be urgently addressed.

The Barthel index was the significant factor documenting both malnutrition risk and malnourishment in the present study. Many researchers agree that there is a relationship between physical function and nutrition status.[12] It might be concluded that individuals whose daily activity is limited tend to avoid shopping for food items, resulting in nutritional disturbance.

In addition to the Barthel index, sex was found to be a significant factor influencing malnutrition risk. The present study showed that older females had a 1.845-fold greater malnutrition risk than older males (95% CI 1.121–3.036), which agreed with the results of a previous study that showed that older females were more likely to develop nutritional disturbance, both obesity and malnutrition.[13]

Furthermore, occlusal status was significantly related to malnutrition risk. The group C individuals (functionally inadequate occlusion with no dentures) had a 3.189-fold greater malnutrition risk than group A (natural dentition with adequate function; 95% CI 1.437–7.080). Chewing efficiency, for example, the rate of breakdown of food during mastication, is clearly correlated with features of the dentition, such as number of posterior teeth and occlusal relationships.[14] The most pronounced difference in intake involves hard-to-chew foods, such as vegetables and some fruits, therefore tooth loss affects elements of nutritional intake, such as dietary fiber and vitamins.[15] These micronutrients are the key element in maintaining good nutrition, which suggests that lack of such food might result in greater malnutrition risk.

In addition, group B (partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws) had a 1.704-fold greater malnutrition risk than group A (95% CI 1.013–2.864). Previous studies have shown that individuals who have lost natural molar contacts consume lesser amounts of hard-to-chew foods, such as vegetables and fruits, even though they use their dentures during food intake.[16] Our findings in the present study support the view that denture use is not sufficient to compensate for natural teeth. Recently, Bradbury *et al.* showed that food instruction encourages an increase in the consumption of vitamins and minerals among new denture wearers.[17] In general, denture treatment has not usually included in such dietary intervention. Future studies will be required to identify the effect of dietary intervention on the prevention of malnutrition in denture users.

In contrast, there was no significant relationship between malnourishment and occlusion in frail elderly participants. There were significant relationships between malnutrition and Barthel index, abnormal swallowing sounds detected by cervical auscultation, and living alone. These results suggest that malnourished elderly have already developed dysphagia resulting in dietary modification;[18] therefore, their malnutrition might be less influenced by a proper occlusal relationship. A vicious cycle, in which decreased ability to

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Table 2 Items significantly involved in malnutrition risk

	B	Standard deviation	Wald	P-value	Exp (B)	95% Confidence interval	
Sex	0.612	0.254	5.803	0.016	1.845	1.121	3.036
Age	−0.001	0.015	0.006	0.939	0.999	0.971	1.028
Charlson index	0.089	0.082	1.168	0.280	1.093	0.930	1.284
Barthel index	−0.036	0.005	43.381	0.000	0.965	0.955	0.975
Clinical Dementia Rating	0.156	0.140	1.251	0.263	1.169	0.889	1.537
Swallowing sounds	0.482	0.297	2.627	0.105	1.619	0.904	2.900
Occlusal relationship (a) group A vs group B	0.533	0.265	4.039	0.044	1.704	1.013	2.864
Occlusal relationship (b) group A vs group C	1.160	0.407	8.125	0.004	3.189	1.437	7.080
Living alone	0.353	0.301	1.380	0.240	1.424	0.790	2.567
Constant	1.701	1.265	1.807	0.179	5.479		

The participants were divided into two groups according to their nutrition status: (i) a well-nourished group; and (ii) a group that included those at risk of malnutrition and malnourished. Group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; group C, functionally inadequate occlusion with no dentures.

Table 3 Items significantly involved in malnutrition

	B	Standard deviation	Wald	P-value	Exp (B)	95% Confidence interval	
Sex	0.613	0.388	2.501	0.114	1.846	0.864	3.947
Age	−0.002	0.021	0.007	0.933	0.998	0.958	1.040
Charlson Index	0.014	0.104	0.019	0.891	1.014	0.827	1.244
Barthel Index	−0.035	0.007	27.940	0.000	0.966	0.953	0.978
Clinical Dementia Rating	−0.072	0.178	0.165	0.685	0.930	0.657	1.318
Swallowing sounds	1.060	0.340	9.684	0.002	2.885	1.480	5.623
Occlusal relationship (a) group A vs group B	−0.453	0.391	1.343	0.246	0.636	0.295	1.368
Occlusal relationship (b) group A vs group C	−0.485	0.520	0.871	0.351	0.616	0.222	1.705
Living alone	1.461	0.403	13.143	0.000	4.312	1.957	9.502
Constant	−0.746	1.777	0.176	0.674	0.474		

Participants were divided into two groups according to their nutritious status: (i) a group of well-nourished individuals and those at risk of malnutrition; and (ii) a group of malnourished individuals. Group A, natural dentition with adequate function; group B, partially or fully edentulous, but maintaining functional occlusion with dentures in either or both jaws; group C, functionally inadequate occlusion with no dentures.

swallow food could accelerate malnutrition, was also considered. Elderly people who live alone are less likely to follow through with dietary modification,[19] and it might lead to malnutrition regardless of occlusal status.

In conclusion, the present study, as well as previous studies, has shown that retaining the natural teeth plays an important role in the prevention of nutritional disturbance, and that early dental treatment in the elderly is important to protect their teeth and occlusion. Dieticians, as well as other care staff, should monitor oral conditions, such as remaining teeth and occlusion, in the elderly in order to prevent malnutrition. We also suggest that all dentists enhance their skills and knowledge in the fields of swallowing function and nutritional guidance.

Acknowledgments

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Original article

A novel rapid oral bacteria detection apparatus for effective oral care to prevent pneumonia

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Objective: To clarify the oral environment, we evaluated the usefulness and clinical applicability of a new apparatus developed for the simple and rapid quantification of oral bacteria.

Background: Professional oral health care can reduce the number of oral bacteria and days of fever and inhibit the development of pneumonia. A novel detection apparatus was developed by applying the dielectrophoretic impedance measurement method.

Methods: First, to determine the accuracy of this apparatus, employing standard samples of *Escherichia coli*. Next, to evaluate the oral environment, samples were taken from the tongue in elderly (mean age: 86.6 years) in nursing home.

Results: In the first study, a good correlation was observed between the two methods ($R = 0.999$). In the second study, there were significant correlations between measurement values obtained using this apparatus and those obtained by the culture method ($R = 0.852$), as well as those obtained by the FM method ($R = 0.885$).

Conclusion: Our data showed that this rapid oral bacterial detection apparatus is effective in evaluating the oral hygiene to prevent pneumonia in the elderly.

Keywords: oral health care, number of oral bacteria, dielectrophoretic impedance measurement.

Introduction

Aspiration pneumonia is an airway infection induced by the aspiration of pathological microorganisms.[1] Oropharyngeal aspiration is an important aetiological factor leading to pneumonia, particularly in the elderly. The incidences of cerebrovascular and degenerative neurologic diseases increase with ageing, and these disorders are associated with dysphagia and an impaired cough reflex, thus resulting in an increased likelihood of oropharyngeal aspiration.[2]

Multiple strategies have been proposed to prevent aspiration pneumonia, including changes in diet consistency (thickened fluids), use of positioning techniques (chin-down position), oral rinsing and, for seniors with feeding tubes, changes in position of the tube or method of food delivery.[3-9]

Many studies on the relationship between aspiration pneumonia and the oral environment have been reported.[10,11] In the oral cavity, there are many bacterial species that can cause pneumonia,[12,13] and selective decontamination to prevent ventilator-associated pneumonia presumes an oropharyngeal source of bacteria.[14] Inglis et al. reported that the major factor in the development of pneumonia was not the type of oral bacteria, but the amount of bacteria aspirated.[15] Professional

oral health care provided by the dentist and dental hygienist is able to reduce the number of oral bacteria,[16,17] reduce the number of days of fever, inhibit the development of pneumonia[18,19] and reduce the mortality rate caused by pneumonia.[19,20] These reports suggested that the dentist and dental hygienist should play the role of preventing pneumonia by professional oral health care.

Methods for the quantification of oral bacteria include the counter method, in which bacteria are directly counted under a microscope, the turbidity-measurement method, in which the turbidity of bacterial solutions is measured using a photoelectric colorimeter after culture, and the colony-count method, in which colonies formed after culture in medium are counted. However, none of these methods allow rapid measurement in clinical settings. The apparatus used in this study was developed by applying the dielectrophoretic impedance measurement (DEPIM) method, consisting of dielectrophoresis and impedance measurement.[21] We then evaluated the effects of oral health care in elderly requiring long-term care and the usefulness of this apparatus in monitoring the degree of contamination in the oral cavity.

Materials and methods

Rapid oral bacteria detection apparatus

The apparatus used in this study consisted of the elements necessary for measurement by the DEPIM method.[21] These elements included an electrode chip to capture bacteria, a cell-retaining sample solution, an alternating current circuit for dielectrophoresis and an impedance measurement circuit. Measurement was initiated by placing the sample solution (about 5 ml) and electrode chip inside the device and pressing a button. The results of measurement were then shown on a liquid crystal display (Fig. 1).

First study to evaluate the relationship between DEPIM method and conventional culture method

To confirm the basic performance for the measurement of bacteria, the relationship between the DEPIM method and the culture method was evaluated using *Escherichia coli* (*E. coli*) K-12 strain (NBRC3301; National Institute of Technology and Evaluation, Tokyo, Japan), which was aerobically cultured in agar medium (MB0010; Eiken Kizai, Tokyo, Japan) at 37°C for 16 h. Cells were harvested and suspended in 0.1 M mannitol.
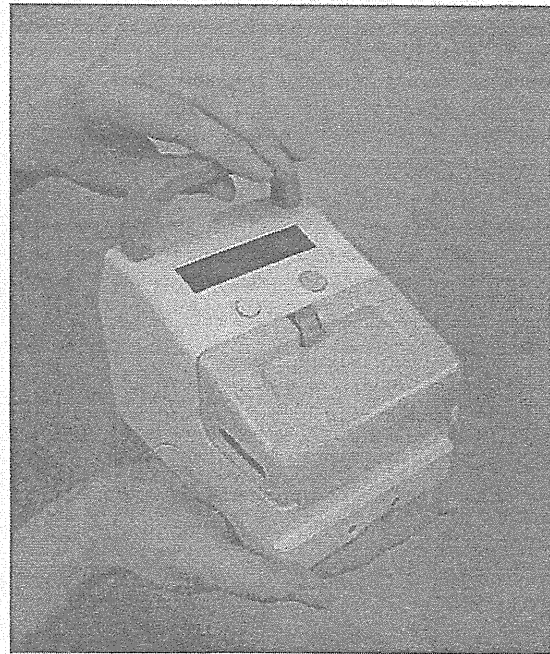

Figure 1 Rapid oral bacteria detection apparatus.

Centrifugation (4500 g, 3 min) and re-suspension were repeated three times, and the solution was diluted to obtain the concentrations of 1.3×10^5, 1.3×10^6 or 1.3×10^7 cfu/ml, and these were subjected to measurement.

For the culture method, bacterial suspensions were spread over agar plates and aerobically cultured at 37°C for 16 h, and bacterial concentrations were determined from the number of colonies on the plates. For the DEPIM method, the oral bacteria detection apparatus was used, and the samples were measured over a period of 20 s, eight times for each diluted sample.

Second study to evaluate the association between DEPIM method and culture method, fluorescence microscopy methods using oral samples

The subjects were 110 elderly residents (84 men and 26 women) aged 86.6 ± 7.6 years (mean age ± SD) in a welfare facility for the elderly requiring long-term care. The samples were collected on three randomly selected days. The number of collected samples was 260. Seventy samples could not be collected because some residents were in a poor condition or ere out of nursing home on the day of sample collecting. Based on the results of the first study, the samples were collected from the median area of the tongue in contact with the

mandibular first molar at 1 h or more after breakfast. Drinking water immediately before sample collection was prohibited. The collection pressure was about 20 g, and a 1-cm distance was rubbed back and forth three times with a swab. The obtained samples were suspended in 7 ml of 0.1 M mannitol, and 5 ml was used as a sample for testing with this apparatus, while the remaining solution was employed as a sample for the conventional culture and fluorescence microscopy (FM) methods. Correlations in data obtained by these methods were then evaluated.

For the culture method, samples were appropriately diluted in 0.1 M mannitol, spread over blood agar plates (1–2 plates for each sample) using a spiral plating apparatus (Autoplate 4000; Spiral Biotech Inc., Norwood, MA, USA), followed by anaerobic culture at 37°C for 48 h. The colonies were counted using a colony counter (Acolyte; Synbiosys, Cambridge, UK), and bacterial concentrations in the samples were determined.

For the FM method, the appropriately diluted samples were stained with diamidino-2-phenylindole, and the bacteria were trapped on membrane filters (A020A047A; Advantec Toyo Roshi Kaisha, Ltd., Tokyo, Japan) observed and counted under a fluorescence microscope (BX51; Olympus Corp, Tokyo, Japan). The bacterial concentrations in the sample were determined by conversion based on the bacterial number in the visual field area.

Statistical analysis

Statistical analysis was performed by means of SPSS 16 for Windows software (SPSS Inc., Chicago, IL, USA). Pearson's correlation coefficient was calculated to study the relationships among the methods, and $p < 0.05$ was considered to be statistically significant.

Ethics

The purpose and procedure of this study was explained to the subjects both orally and in writing, and written informed consent was obtained from all participants. The study was approved by the Ethics Committee of The Nippon Dental University School of Life Dentistry at Tokyo.

Results

First study

When the amount of bacteria was measured using the DEPIM method or the conventional culture

method, a significant correlation ($R = 0.999$, $p < 0.01$) was observed between the measured values (Fig. 2).

Second study

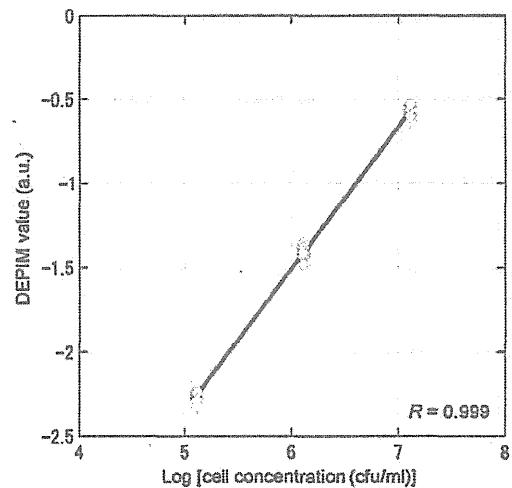There were significant correlations between measurement values obtained using this apparatus and

Figure 2 Relationship between dielectrophoretic impedance measurement (DEPIM) method and culture method (*Escherichia coli*). There was a significant correlation between the DEPIM and conventional culture methods ($R = 0.999$, $p < 0.01$).
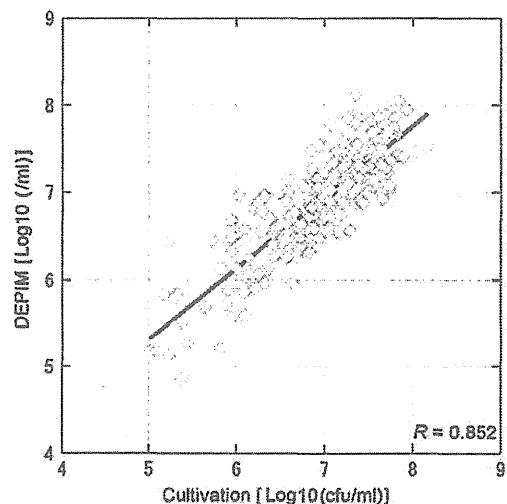
Figure 3 Relationship between dielectrophoretic impedance measurement (DEPIM) method and culture method. There was a significant correlation between the DEPIM and culture methods ($R = 0.852$, $p < 0.01$).

those obtained by the culture method ($R = 0.852$, $p < 0.01$), as well as those obtained by the FM method ($R = 0.885$, $p < 0.01$). Moreover, there was a significant correlation between the data obtained by the culture method and those obtained by the FM method ($R = 0.934$, $p < 0.01$) (Figs 3–5).

Discussion

In the long-term care of elderly individuals, the incidence of aspiration pneumonia as a serious complication is high.[22,23] Oral health care is an important preventative measure against aspiration pneumonia in the elderly.[18,19] When aspiration pneumonia becomes serious, high medical costs related to hospital admission and medications are inevitable. To prevent aspiration pneumonia through oral health care maintains cost efficiency; lower-cost interventions in oral hygiene thus reduce some of the higher-cost outcomes of aspiration pneumonia.[24] People requiring or receiving care often cannot adequately maintain oral hygiene alone.[25,26] Therefore, caregivers and nursing staff are essential to maintain their oral environment, evaluation of oral conditions, planning of oral health care and oral health care by dental staff. Furthermore, to effectively design and conduct an oral health care plan, the state of oral health of individuals must first be clarified.

There are various bacterial species that cause aspiration pneumonia, with the major factor in the development of pneumonia being the amount rather than the type of oral bacteria aspirated.[15] Thus, measurement of the number of bacteria should be important in assessing the risk of aspiration pneumonia. In the field of dentistry, the amount of *Candida albicans* has been measured for the diagnosis of oral candidiasis, and the amounts of streptococci and lactobacilli have also been measured in plaque and saliva to evaluate the risk of caries. Methods to prevent these diseases and to reduce their risks have frequently been used in clinical practice. These methods include simple evaluations employing a colorimetric reagent that reacts with the acid metabolites of microorganisms[27] and the evaluation of colonies formed on selective media after culture.[28,29] On the other hand, as oral care parameters, observation of dental plaque accumulation[30,31] and tongue coating status[32,33] have been clinically applied, with both techniques found to be subjective.

The present apparatus using the DEPIM method, consisting of dielectrophoresis and impedance measurement, requires only 20 s for a measurement and can be readily performed in a short period of time by any examiner.[34] The results of this study showed a high correlation between data obtained by the DEPIM method and the conventional culture method using *E. coli* samples, as well as between the DEPIM method and both the culture and FM methods using oral samples containing a mixture of various bacterial species.
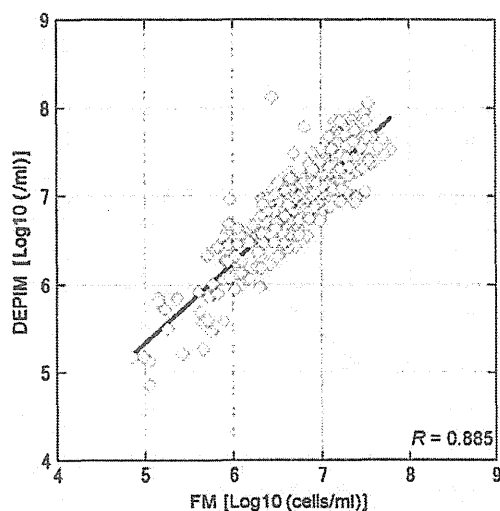
Figure 4 Relationship between dielectrophoretic impedance measurement (DEPIM) method and fluorescence microscopy (FM) method. There was a significant correlation between the DEPIM and FM methods ($R = 0.885$, $p < 0.01$).
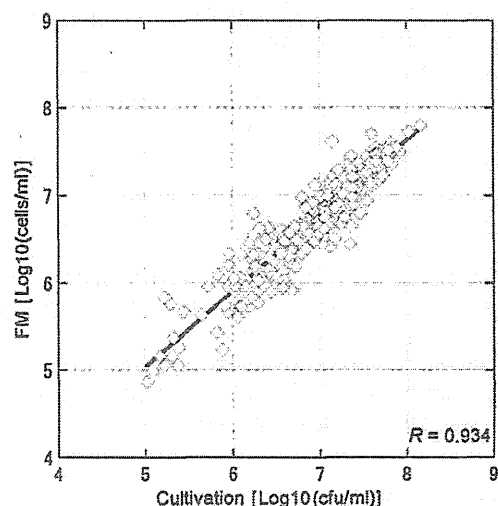
Figure 5 Relationship between culture method and fluorescence microscopy (FM) method. There was a significant correlation between the culture and FM methods ($R = 0.934$, $p < 0.01$).

Conclusion

The present apparatus is useful for measuring the number of oral bacteria and could be important in maintaining the quality of oral health care.

Acknowledgements

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FACTORS ASSOCIATED WITH DETERIORATION OF MINI NUTRITIONAL ASSESSMENT-SHORT FORM STATUS OF NURSING HOME RESIDENTS DURING A 2-YEAR PERIOD

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Abstract: *Objective:* A number of other studies have been conducted to verify the Mini Nutritional Assessment (MNA) or the MNA short form (MNA-SF) as a nutritional assessment/screening tool in various clinical settings or communities. However, there are few longitudinal studies using these tools to analyze which factors affect the incidence of deteriorating nutritional status. We tried to identify the factors associated with deterioration of MNA-SF status of nursing home residents during a 2-year period. *Methods:* Participants were 392 people with a mean age of 84.3 in 12 nursing homes in Japan. The factors associated with deterioration in MNA-SF categories during the study period compared to stable/improved MNA-SF categories were identified. *Results:* At baseline, 19.9% of the participants were malnourished and 60.2% were at risk of malnutrition, according to the MNA-SF classification. After 2 years, 66.3% participants maintained and 6.1% participants improved their nutritional status according to the MNA-SF classification, while 27.6% showed deterioration in MNA-SF status. Stepwise logistic-regression procedure indicated that basic ADL impairment and hospitalization during the follow-up period were associated with declining MNA-SF status. *Conclusions:* Poor basic ADL status and hospitalization during the follow-up period were associated with malnutrition and risk of malnutrition as assessed by MNA-SF of nursing homes residents during a 2-year period.

Key words: The factors associated with deterioration of Mini Nutritional Assessment-Short Form stage, frail elderly, nursing home.

Introduction

Japan has the most rapidly aging population in the world and soon will have the largest percentages of elderly and very elderly in its population. In 2011, the rate of the population over age sixty-five was 23.3%. Elderly persons 100 years or older numbered 47,756 and 87.1% of these were women. The numbers of frail elderly people living in the community or institutions for the aged are increasing, along with their hospital admissions.

The nutritional status of older people is an important determinant of quality of life, morbidity and mortality (1-3). The relationship between poor nutritional status and impaired immune functions, the development of pressure sores, and impaired muscle function is well established (4-6). Therefore, it is quite important for the elderly to maintain good nutritional status.

The Mini-Nutritional Assessment (MNA) is a simple clinical scale for the evaluation of the nutritional status of frail elderly subjects (4, 7, 8). We evaluated the MNA test as a screening tool for malnutrition in the Japanese elderly population and concluded that the MNA full test is a useful screening tool for identifying Japanese elderly with malnutrition or a risk of malnutrition (9). A number of other studies have been conducted to verify the MNA or the MNA short form (MNA-SF) as a nutritional assessment/screening tool in various clinical settings or communities. However, there are few longitudinal studies using these tools to analyze which factors affect the incidence of deteriorating nutritional status.

In the present prospective study we tried to identify the factors associated with deterioration of MNA-SF status of residents of nursing homes during a 2-year period.

Methods

Subjects

The study population consisted of 649 residents of 12 nursing homes located in Nagoya City (116 men and 533 women, age 65 years or older). Twelve nursing homes belonged to a single social welfare corporation and staffs of nursing homes received the same education training. The dietitians carry out the nutritional assessment of the nursing home residents according to the Long-Term Care Insurance (LTCI) program. These participants, who were enrolled between May 1 and June 30, 2009, were scheduled to undergo comprehensive assessments by trained nursing home staff at baseline, and at 12 and 24 months. At 3-month intervals, data were collected about any important events in the lives of the participants, including admission to the hospital, and mortality. Written informed consent for participation, according to procedures approved by the institutional review board of Nagoya University Graduate School of Medicine, was obtained from the residents or, for those with substantial cognitive

impairment, from a surrogate (usually the closest relative or legal guardian).

Data collection

The data were collected at the nursing homes using structured interviews with residents and nursing home staff, and from nursing home records taken by trained nurses. The data included clients' demographic characteristics and a rating for ten basic Activities of Daily Living (ADL: getting out of bed, transferring, walking, bathing, grooming, dressing, putting on and taking off pants, feeding, bowel and bladder management). For each ADL task, nurses rated residents as independent (a score of 10, able to perform the activity without help), partially dependent (a score of 5, requiring some assistance), or completely dependent (a score of 0, needing help for the entire activity). The sum of these scores theoretically range from 0 (total disability) to 100 (no disability). Nurse ratings were based on direct observation, interviews with residents, and information from staff. Information obtained from nursing homes records included data on the following physician-diagnosed chronic conditions: ischemic heart disease, congestive heart failure, cerebrovascular disease, diabetes mellitus, dementia, cancer, neurodegenerative disorders including Parkinson's disease, and other diseases comprising the Charlson Comorbidity Index (10), which represents the sum of weighted indexes taking into account the number and seriousness of preexisting comorbid conditions. Chewing ability was categorized into three groups: difficulty chewing even soft food items such as boiled rice, tuna sashimi, and grilled eel (poor), difficulty chewing harder foods such as hard rice crackers, peanuts, and yellow pickled radish (fair), and no difficulty chewing harder foods (good). Dietitian ratings were based on direct observation and information from other staff.

Anthropometry

Height and weight data were generally measured at the nursing homes and collected by trained staff. Weight was measured in light clothing without shoes using a portable weight scale at the nursing homes. Height was generally measured in an upright position using a tape measure attached to the wall. However, when participants could not maintain an upright position, height measurements were obtained in a prone position.

Nutritional Assessment

The MNA-SF is composed of a combination of six questions taken from the full MNA about appetite loss, weight loss, mobility, stress/acute disease, dementia/depression, and body mass index (BMI). The score of the MNA-SF was used to classify subjects' nutritional status as well-nourished (a score of 12-14), at-risk for malnutrition (a score of 8-11), or malnourished (a score of 0-7). The MNA-SF was administered by dietitians, except for the mental state questionnaire which was obtained from nursing staff members or medical records at baseline, at 1 year later and at 2 years later.

Study participants

Among 450 survivors, the participants who stayed in the nursing home and were re-assessed at both baseline and at 2 years later were 392. The 60 participants who were assessed as malnourished according to the MNA-SF at both baseline and at 2 years later were excluded from our analysis to identify the factors associated with becoming malnourished or at risk of malnutrition.

Statistical analysis

The Student's t-test and Chi-squared test were used to compare differences between participants with the MNA-SF stage decline and those without decline (improved or stable MNA-SF stage). The 392 study participants were divided into tertiles according to the basic ADL score at baseline (first, 55-100; second, 20-50; third, 0-15). The significance level was set at $P < 0.05$ and quoted are two-sided.

Univariate and multivariate logistic regression models were used to identify independent predictors of declining MNA-SF status. The following baseline data were used in univariate analysis: gender, age, basic ADL, ability of chewing, and hospitalization during the 2-year period. The covariates included in the multivariate analysis were those variables associated with dependent variables at a level of $P < 0.05$ in univariate analysis. Stepwise logistic-regression procedure was conducted. The risk of a variable was expressed as an odds ratio (OR) with a corresponding 95% confidence interval (CI).

All analyses were performed using the Statistical Package for the Social Sciences (SPSS) Version 20.0. A probability value of 0.05 or less was considered significant.

Results

Among the 649 participants, 199 subjects died during the 2-year study period. It should be noted that mean MNA-SF score of 199 at the base line was significantly lower than that of 450 survivors (8.2 (SD 2.0) vs 9.3 (SD 2.4), $P < 0.001$).

Table 1 shows the characteristics of the 392 participants at baseline. The mean age was 84.3 (SD 7.21) years, with 49.7% of the subjects 85 years or older and 82.9% of them women. The mean BMI, MNA-SF score and basic ADL score were 20.3 (SD 3.7) kg/m², 9.3 (SD 2.3) points, and 37.3 (SD 29.7) points, respectively. The participants had a high prevalence of dementia (56.9%), cerebrovascular disease (49.9%) and hypertension (46.4%). Among the 392 participants, 20.1% participants had poor chewing ability.

At baseline, 19.9% of the participants were malnourished and 60.2% were at risk of malnutrition, according to the MNA-SF classification (Table 1). As shown in table 2, after 2 years, 37.2% of the participants were classified as malnourished and 49.2% were at risk of malnutrition, according to the MNA-SF classification. Among the 392 participants, 260 (66.3%)

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Table 1
Baseline characteristics of the 392 frail elderly

	n	% of total	mean	SD
		total (n 392)		
Age (years)	392		84,3	7,2
Body Mass Index (kg/m²)	392		20,3	3,7
MNA-SF score (max. 14 points)	392		9,3	2,3
MNA-SF classification				
malnourished	78	19,9		
at risk of malnutrition	236	60,2		
well-nourished	78	19,9		
Charlson comorbidity index (range, 0-19)	392		2,3	1,6
Chronic diseases				
dementia	223	56,9		
cerebrovascular disease	195	49,9		
hypertension	182	46,4		
heart failure	61	15,6		
ischemic heart disease	62	15,8		
diabetes mellitus	60	15,3		
Parkinson's disease	24	6,1		
Basic ADL (range, 0-100)	392		37,3	29,7
Chewing ability				
good	129	33,2		
fair	181	46,6		
poor	78	20,1		

Table 2
Mini Nutritional Assessment Short Form status at baseline and at 2-year follow-up

Baseline MNA-SF	Malnourished	At risk of malnutriton	Well-nourished	Total
	MNA-SF status at 2-yr follow-up			
Malnourished				
number of participants	60	18	0	78
% of baseline	76,9%	23,1%	0,0%	100,0%
% of at 2-year	41,1%	9,3%	0,0%	19,9%
At risk of malnutrition				
number of participants	77	153	6	236
% of baseline	32,6%	64,8%	2,5%	100,0%
% of at 2-year	52,7%	79,3%	11,3%	60,2%
Well-nourished				
number of participants	9	22	47	78
% of baseline	11,5%	28,2%	60,3%	100,0%
% of at 2-year	6,2%	11,4%	88,7%	19,9%
Total				
number of participants	146	193	53	392
% of baseline	37,2%	49,2%	13,5%	100,0%
% of at 2-year	100,0%	100,0%	100,0%	100,0%

participants maintained and 24 (6.1%) participants improved their nutritional status according to the MNA-SF classification (18 moved from "malnutrition" to "at risk of malnutrition"; 6 from "at risk" to "normal nutrition"), while 108 (27.6%) showed deterioration of MNA-SF categories during the study period (9 from normal nutrition to malnutrition, 22 from normal nutrition to at-risk status, and 77 from at-risk to malnutrition). Sixty (15.3%) participants were assessed as

malnourished at both baseline and at 2 years later (Table 2). Therefore, the number of participants with improved/stable and deteriorating status according to MNA-SF classification, after excluding participants with malnutrition at both baseline and follow-up, were 224 and 108, respectively.

Table 3 compares the baseline characteristics of participants whose MNA-SF status deteriorated and remained stable/improved during the 2-year period. No differences were