The Association between Periodontal Disease and Malnutrition in A Group of Elderly People in Thailand

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Abstract

The aim of this study was to determine the association between periodontal disease and malnutrition status in older adults. The factor(s) which are related to malnutrition in older adults with periodontal disease were investigated. Participants ≥ 60 years old with functional and cognitive independent were included in this cross-sectional study. Sociodemographic data, anthropometric measurements, self-rated chewing, periodontal status, number of teeth and functional tooth units (FTUs) were recorded. The Mini Nutritional Assessment (MNA) was used for nutritional status assessment. Eighty-two participants were included in the study. Two groups including normal nutrition group (82.9%) and at risk of malnutrition group (17.1%) were found. A significant association between periodontal disease and risk of malnutrition was not found from this study (p=0.557). A significant difference in nutritional status was found according to education levels (p=0.009). The percentage of participants with insomnia and osteoarthritis was significantly higher in the at risk of malnutrition group than in the other group (p=0.003 and 0.042). It was noticeable that more participants with depression were found in the at risk of malnutrition group than in the other group (14.3% vs 1.5%). Then an association between periodontitis and malnutrition in older adults was not found in this study. The current study suggests an association between insomnia, osteoarthritis and depression with risk of malnutrition. Thus, older adults with these symptoms may be at risk of malnutrition and further study is needed to answer these questions.

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Introduction

The phenomenon of population aging due to declining fertility rate and rising life expectancy is occurring throughout the world.[1] Virtually every country in the world is experiencing growth in the number and proportion of older persons in their population.

Aging may be accompanied with an accumulation of diseases and impairments caused by physiological, socioeconomic and psychological changes. Older adults are more prone to nutritional deficiencies due to a combination of factors[2] such as aging, excessive polypharmacy, general health decline, poor socioeconomic status, cognitive decline, poor appetite, impaired efficacy of swallowing [3-6] and limited eating ability.[7-9] Malnutrition is one of the important problems in older adults. A previous study found that the prevalence of malnutrition was 22.8%, with considerable differences between settings with a prevalence of 50.5% in older adults in geriatric rehabilitation, 38.7% in hospitalized elderly patients, 13.8% in nursing home settings and 5.8% in community settings.[10]

The European Society of Clinical Nutrition and Metabolism (ESPEN) recommended to use Mini Nutrition Assessment (MNA) to assess nutritional status in older adults.[11] MNA items specifically address relevant features of the aging population that allow for early detection of malnutrition risk and enable assessors to take immediate action. Therefore, performing the MNA as a screening test is strongly recommended as the basis for nutritional evaluation in older people.[10]

Periodontitis and poor oral hygiene are the causes of tooth loss in older adults and affected eating behavior of

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older adults to choose more soft diet that is easily masticated.[12, 13] Tooth mobility, number of tooth loss, number of natural teeth, functional tooth units (FTUs) and chewing ability are also associated with the quantity and quality of food intake in older adults.[14-18] Moreover, functional and muscular impairments have an impact on the ability to perform effective self-care in older adults. These changes in older adults are significant effects in periodontal disease progression.[19] Therefore, aging has been suggested to increase risk of periodontitis in older adults.[20] Furthermore, many studies have found that periodontitis also has a negative impact on nutritional status and quality of life in older adults.[21-26]

In the pathogenesis pathways of periodontal disease, the first cytokines of innate immune response are tumor necrosis factor alpha (TNF-α), interleukin-1 beta (IL-1β) and interleukin-6 (IL-6).[27] Interferon gamma (IF-γ) is presented at high levels in periodontal lesions and is associated with progressive or severe form of periodontitis.[28] The effects of aging on the immune system resulting in processes of immunosenescence, immunoactivation and inflammaging.[29] In inflammaging, the increased of low-grade chronic systemic pro-inflammatory cytokines such as IL-6 and TNF-α can lead to sarcopenia and frailty in older adults.[30]

The association between periodontal disease and systemic disease through inflammatory cytokines has been reported. Periodontal disease and chronic kidney disease (CKD) share several systemic pro-inflammatory comorbidities, suggesting that chronic low-grade inflammation may play a crucial role in linking these diseases and that perhaps periodontitis is hidden comorbidity of CKD.[31] Inflammatory bowel disease (IBD) is a chronic inflammatory condition involving the gut. Hence, IBD and periodontitis have distinct characteristics, several aetiologies and pathogenesis are quite similar. Inflammatory cytokines such as IFN-γ, IL-6 and TNF-α can be detected in both periodontal disease and IBD.[32] Several studies found an association between CKD and IBD with malnutrition.[33-36] In CKD, protein-energy malnutrition (PEM) and inflammation are common and usually concurrent in maintenance hemodialysis patients, defined as "malnutrition-inflammation complex syndrome" (MICS).[37]

Periodontitis is associated with diabetes mellitus (DM) in a bidirectional relationship. Meta-analysis indicates that elevated levels of inflammatory cytokines and inflammatory marker such as IL-1β, IL-6, TNF-α, C-reactive protein (CRP) and low levels of adiponectin are strongly associated with type 2 DM.[38] Aging is associated both with a progressive decline in glucose tolerance and coincidentally with increasing prevalence of periodontitis.[39] A longitudinal study in Japan found a negative correlation of vegetable intake and a positive correlation of carbohydrate and sugar intake with periodontal disease events.[40] In 2017, a literature review found that gingival bleeding and destructive periodontal disease are sensitive markers of both abnormalities in macronutrient content (excessive carbohydrates or poly-unsaturated fat intake, deficient protein intake) and micronutrient intake (e.g. vitamin C and B12).[41] Thus, inflammation and dietary intake in the elderly can lead to malnutrition in patients with DM and periodontitis.

Collectively, we conclude that there is a link between periodontal disease and malnutrition via many pathways i.e., tooth loss and decrease in chewing ability, chronic inflammatory diseases such as type 2 DM, CKD, IBD and inflammaging from aging. However, the relationship between periodontal disease and malnutrition in older adults is still not clear and needs further study. The aim of this study was to determine the association between periodontal disease and malnutrition status in older adults. The factor(s) which are related to malnutrition in older adults with periodontal disease were also investigated.

Materials and Methods

Population

Prior to the study, sample size was calculated with substitution of the proportions of malnutrition participants with healthy gingiva/gingivitis ($p_1 = 0.32$) and periodontitis ($p_2 = 0.68$) from a previous study.[42] At a 2-sided type I error probability of 0.05 and, 90% power of detection, a sample size at least 39 participants per group was required.

The study was approved by the Institutional Review Board of Faculty of Dentistry and Faculty of Pharmacy, Mahidol University, Bangkok, Thailand for ethical aspects (MU-DT/PY-IRB 2019/DT087). Informed consent forms were obtained from all participants who decided to enroll in the study. This cross-sectional study was performed at Maha Chakri Sirindhorn Dental Hospital, Golden Jubilee Medical Center and Periodontology and Oral Medicine Clinic, Faculty of Dentistry, Mahidol University, Thailand during January 2020 – February 2021. The inclusion criteria were 1) aged ≥ 60 years old, 2) not received periodontal treatment within the previous 6 months, 3) able to read Thai and express verbal communication, 4) functional independent older adults (score ≥12 points from Barthel Index for Activities of Daily Living),[43, 44] 5) cognitively functional independent older adults (score >23 points from Thai Mental State Examination).[45] Participants with a completely edentulous area or required antibiotic prophylaxis for dental examination were excluded from this study. A total 82 participants were included in this study.

Examiner calibration

An intra-examiner calibration process for probing pocket depth (PPD) and clinical attachment level (CAL) measurements was conducted. Ten randomly selected volunteer patients were examined twice at an interval of 1 week. The intraclass correlation coefficients for the intra-examiner reproducibility were 0.76-0.92 for PPD and 0.83-0.93 for CAL.

Questionnaire Survey

The questionnaire was completed through an interview with a trained interviewer.

1. Sociodemographic and health behavior characteristics

The questionnaire was used to collect sociodemographic and health behavioral information including age, gender, nationality, marital status, education, working status, income, smoking status, and alcohol consumption. Medical history of chronic diseases which were diagnosed by physicians and regular medication which had side effects as loss of appetite (metformin, metronidazole, amphotericin B, formoterol fumarate, tiopium and hydralazine hydrochloride) [46,47] were also recorded during the interview.

2. Anthropometric measurements

Body mass index (BMI) was calculated as the ratio of weight in kilograms to the square of height in meters (kg/m^2). Obesity was defined as individuals with body mass index 30 kg/m^2 and over.[48]

3. Nutritional status assessment

The MNA was used for nutritional status assessment of older adults. It comprises 18 items and the score is calculated using an assigned weighted number for each item. Possible scores range from 0 to 30. Scores ≥24 were classified as having a normal nutritional status, scores from 17 to 23.5 were classified as at risk of malnutrition, and scores <17 were classified as malnutrition.[49]

4. Masticatory ability assessment

Self-rated chewing ability was assessed by using 12 Thai foods that ranged from easy to difficult to chew: 1) rice porridge 2) well-cooked rice 3) noodles 4) steamed glutinous rice 5) green corn 6) papaya in papaya salad 7) fried meat balls 8) grilled meat/ pork 9) fried chicken 10) pah taung goh (a kind of Chinese flour with sweet meat) 11) grilled dry cuttlefish and 12) an ice cube. The interviewer showed photographs of food items and asked the participants which food they were able to chew. The maximum score of the chewing ability test was 12. Participants were divided into 2 groups; the poor chewing ability group scored 0-7 and the good chewing ability group scored 8-12.[14]

Data collection

Periodontal status, number of teeth and functional tooth units (FTUs) were also recorded by the calibrated researcher.

Periodontal parameters including mean probing pocket depth (PPD), mean clinical attachment level (CAL), bleeding on probing (BOP), and gingival index (GI) in all present teeth except third molar were collected. Plaque Index (PI) was assessed from six surfaces of selected four posterior and two anterior teeth except the third molar.

PPD and CAL were assessed using a standard periodontal probe (PCPUNC 15, Hu-Friedy™, IL, USA). PPD and CAL were recorded at 6 sites around each tooth (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual and disto-lingual) and the mean of PPD and CAL were calculated for each participant.

For BOP assessment, a standard periodontal probe was used for gentle probing of six sites around each tooth. Thirty to sixty seconds later, the presence or absence of bleeding upon probing was recorded before the percentage of bleeding sites was calculated.[50]

GI was measured by assessing the gingival inflammation in the mesial, distal, buccal and lingual regions of each tooth except the third molar. Based on the degree of inflammation, each site was allocated a score from 0 to 3 as follows: 0 = normal gingiva, 1 = mild gingival inflammation, 2 = moderate gingival inflammation and 3 = severe gingival inflammation.[51] The mean GI for each participant was also calculated.

The simplified oral hygiene index was used to record the PI, an explorer was passed along the tooth surface to test for the presence of plaque. Four different scores were possible. A zero score indicated no plaque or stains present; 1 indicated soft plaque covering not more than one third of the examined tooth surface or the presence of extrinsic stains without plaque regardless of surface area covered; 2 represented soft plaque covering more than one third but not more than two thirds of the exposed tooth surface; 3 represented soft plaque covering more than two thirds of the exposed tooth surface.[52]

The presence of 4 or more teeth with 1 or more sites with PPD $\geq$ 4 mm and with clinical attachment loss $\geq$ 3 mm at the same site was diagnosed as periodontitis.[53]

The number of teeth present in each participant were recorded.[54] FTUs were defined as pairs of upper and lower opposing natural teeth (i.e., sound, restored, and functional carious teeth) or artificial teeth on fixed and removable prostheses. FTUs that involved two opposing anterior or premolar teeth were defined as one FTU, and those with two opposing molars were defined as two FTUs.[55]

Statistical Analysis

The questionnaire scores were summarized in each part for each individual. The complete data was managed into a prepared database for analysis. Prevalence of nutritional status in each periodontal disease group was calculated to percent. Relative prevalence of periodontal disease between nutritional status group were computed. Descriptive analysis was carried out for each variable. Mean, standard deviation and frequency distribution were calculated for variables which were normally distributed. Median, P_{25} and P_{75} were calculated for variables which were not normally distributed. Chi-squared tests were performed to compare categorical variables such as gender, income, periodontal disease, hyperlipidemia and other systemic diseases which were not indicated in questionnaire with nutritional status. Fisher's exact tests were performed to compare categorical variables where there were fewer than five cases in the given cell such as marital status, education, work status, smoking status, alcohol consumption, Anterior functional tooth units (A-FTUs), chewing ability, systemic disease, regular medication related with loss of appetite. Two-sample *t*-test were used to compare continuous variables such as age, mean BMI with nutritional status. Mann-Whitney U tests were used to compare continuous variables followed the non-parametric distribution such as periodontal parameters, number of natural teeth, number of artificial teeth, posterior functional tooth units (P-FTUs), total functional tooth units (T-FTUs), and median chewing ability score with nutritional status. The level of significance was considered at $p<0.05$. Statistical analyses were performed using a statistical software package for the Social Sciences 18.0 (SPSS 18.0, SPSS Inc. Chicago, IL, USA).

Results

Eighty-two participants (36 males and 46 females) were recruited in this study. Although the MNA divides nutritional status into 3 groups according to the score levels, in this study we had no participants in the malnutrition group therefore only 2 nutritional status groups were present as 1) normal nutrition (n=68, 82.9%) and 2) at risk of malnutrition (n=14, 17.1%) (Table 2). As shown in Table 1, the mean ages of participants in the normal nutrition group and the at risk of malnutrition group were 66.7±5.5 years and 69.1±5.2 years,

respectively. The number of females was numerically higher than males in both groups (p=0.063). A statistically significant difference in nutritional status was found according to education levels (p=0.009), with the difference observed between relationship each level of education, i.e., primary school vs secondary school (p=0.006) and primary school vs higher education (p=0.033) (data not reported in the table). In addition, the BMI of participants in the normal nutrition group was significantly higher than in the at risk of malnutrition group (p=0.006).

As shown in Table 2, fourteen participants (17.1%) had nutritional status in the at risk of malnutrition group. Six participants (14.6%) in the at risk of malnutrition group had healthy gingiva/gingivitis and 8 participants (19.5%) had periodontitis. A significant association between periodontal disease and risk of malnutrition was not found in this study (p=0.557).

Table 1 Comparison of socio-demographic, health behaviour and anthropometric characteristics between normal nutrition group and at risk of malnutrition group.

Variables	Nutritional status: n (%)		p-value
	Normal (n=68)	At risk of malnutrition (n=14)	
Age (years)[a]	66.7 ± 5.5	69.1 ± 5.2	0.140[b]
Gender			
Male	33 (48.5)	3 (21.4)	0.063[c]
Female	35 (51.5)	11 (78.6)	
Marital status			
Single	6 (8.8)	2 (14.3)	0.097[d]
Marriage	55 (80.9)	8 (57.1)	
Divorce, Widow	7 (10.3)	4 (28.6)	
Education			
Primary school	2 (2.9)	4 (28.6)	0.009[d]
Secondary school	19 (27.9)	4 (28.6)	
Higher education	47 (69.2)	6 (42.8)	
Work			
Yes	15 (22.1)	1 (7.1)	0.283[d]
No	53 (77.9)	13 (92.9)	
Income (THB/month)			
≤ 23,700	36 (52.9)	7 (50.0)	0.841[c]
> 23,700	32 (47.1)	7 (50.0)	
Smoking			
Non-smoker	50 (73.5)	12 (85.8)	0.157[d]
Former-smoker	17 (25.0)	1 (7.1)	
Smoker	1 (1.5)	1 (7.1)	
Alcohol consumption			
No	44 (64.7)	10 (71.5)	1.000[d]
≤ 1 time/month	15 (22.1)	3 (21.4)	
> 1 time/month	9 (13.2)	1 (7.1)	
BMI[a]	23.7 ± 2.8	21.3 ± 3.3	0.006[b]

[a] Mean ± SD [b] Two-sample t-test [c] Pearson Chi-square [d] Fisher's exact test
THB (Thai Baht) BMI (Body Mass Index)

Table 2 Comparison of periodontal disease between normal nutrition group and at risk of malnutrition group.

Disease (n=41 per group)	Nutritional status		p-value
	Normal n (%)	At risk of malnutrition n (%)	
Healthy gingiva/Gingivitis	35 (85.4)	6 (14.6)	0.557[a]
Periodontitis	33 (80.5)	8 (19.5)	
Overall	68 (82.9)	14 (17.1)	

[a] Pearson Chi-square

In the at risk of malnutrition group, the prevalence of participants with healthy gingiva/gingivitis was 42.9% and with periodontitis was 57.1% as shown in Table 3. The relative prevalence of periodontitis between the at risk of malnutrition and the normal nutrition groups was 1.17 and the relative prevalence of healthy gingiva/gingivitis between the at risk of malnutrition and the normal nutrition groups was 0.83.

PI, GI, BOP, mean PD and mean CAL in the at risk of malnutrition group were higher than in the normal nutrition group but the differences between the groups in this study were not statistically significant (p>0.05) as show in Table 4.

The number of natural teeth present in normal nutrition group was higher than in the at risk of malnutrition group [23 (20, 26) vs 21.5 (19.8, 25.3)]. On the other hand, the number of artificial teeth was higher in the at risk of malnutrition group than in the normal nutrition group [5 (1.8, 11) vs 4 (1, 7.8)], but the difference between groups was not statistically significant for both these parameters (p>0.05).

FTUs in the normal nutrition group was not significantly different from the at risk of malnutrition group (p>0.05). Most of the participants in the normal nutrition group and the at risk of malnutrition group had 6 A-FTUs (n=61; 89.7% and n=11; 78.6% respectively). Median of P-FTUs and T-FTUs were also similar in both groups, no significant differences were found (p>0.05) as show in Table 5.

All participants in both nutritional status groups had good chewing ability (score 8-12). While the median chewing ability in the normal nutrition group was higher than in the at risk of malnutrition group [12.0 (11.3, 12.0) vs 11.5 (11.0, 12.0)], the difference was not statistically significant (p=0.095).

As shown in Table 6, this study found that almost all the participants (n=72, 87.8%) had systemic diseases. Of the participants in the at risk of malnutrition group, 100 % had systemic diseases. When comparing the incidence of each disease between the two groups, this study revealed that the percentage of participants with insomnia and osteoarthritis in the at risk of malnutrition group were significantly higher than in the normal nutrition group (p=0.003 and p=0.042 respectively). It was noticeable that the percentage of participants with depression in the at risk of malnutrition group was higher than in the normal nutrition group (14.3% vs 1.5%) but this difference was not statistically significant (p=0.074).

Table 3 Comparison of prevalence of periodontal disease between normal nutrition group and at risk of malnutrition group.

Disease	Nutritional status		Relative prevalence
	Normal (n=68)	At risk of malnutrition (n= 14)	
Healthy gingiva/Gingivitis (n=41)	51.5 %	42.9 %	0.833
Periodontitis (n=41)	48.5 %	57.1 %	1.177

Table 4 Comparison of periodontal parameters between normal nutrition group and at risk of malnutrition group.

Periodontal parameters	Nutritional status: median (P_{25}, P_{75})		p-value*
	Normal (n=68)	At risk of malnutrition (n=14)	
Plaque index (PI)	1.00 (1.00,1.38)	1.33 (1.00,1.69)	0.210
Gingival index (GI)	0.60 (0.42,0.89)	0.67 (0.43,0.92)	0.702
Bleeding on probing (BOP)	22.67 (12.71,44.21)	27.92 (17.45,45.21)	0.441
Mean PD	2.27 (2.14,2.50)	2.34 (2.16,2.60)	0.438
Mean CAL	2.61 (2.13,3.17)	2.99 (2.07,3.62)	0.546

* Mann-Whitney U test

Mean PD (Mean probing depth)

Mean CAL (Mean clinical attachment level

Table 5 Comparison of numbers of teeth, functional tooth units and chewing ability between normal nutrition group and at risk of malnutrition group.

Variables	Nutritional status: n (%)		p-value
	Normal (n=68)	At risk of malnutrition (n=14)	
Total natural teeth[a]	23 (20,26)	21.5 (19.8,25.3)	0.512[b]
Total artificial teeth[a]	4 (1,7.8)	5 (1.8,11)	0.355[b]
A-FTUs			
3	2 (2.9)	0	0.255[c]
4	2 (2.9)	1 (7.1)	
5	3 (4.4)	2 (14.3)	
6	61 (89.7)	11 (78.6)	
P-FTUs[a]	10 (8,12)	10 (7.8,10)	0.283[b]
T-FTUs[a]	16 (14,18)	15.5 (13.8,16)	0.347[b]
Chewing ability[a]	12.0 (11.3,12.0)	11.5 (11.0,12.0)	0.095[b]
8	1 (1.5)	0	0.198[c]
9	2 (2.9)	0	
10	4 (5.9)	2 (1.43)	
11	10 (14.7)	5 (35.7)	
12	51 (75.0)	7 (50.0)	

[a] Median (P_{25}, P_{75}) A-FTUs (Anterior functional tooth units)
[b] Mann-Whitney U test P-FTUs (Posterior functional tooth units)
[c] Fisher's exact test T-FTUs (Total functional tooth units)

Table 6 Comparison of systemic diseases between normal nutritional group and at risk of malnutrition group.

Variables	Nutritional status: n (%)		p-value
	Normal (n=68)	At risk of malnutrition (n=14)	
Systemic diseases			
No	10 (14.7)	0	0.198[a]
Yes	58 (85.3)	14 (100)	
Diabetes mellitus	6 (8.8)	2 (14.3)	0.619[a]
Hypertension	21 (30.9)	6 (42.9)	0.533[a]
Hyperlipidemia	26 (38.2)	4 (28.6)	0.494[b]
Heart disease	3 (4.4)	0	1.000[a]
Depression	1 (1.5)	2 (14.3)	0.074[a]
Stress	4 (5.9)	2 (14.3)	0.271[a]
Insomnia	3 (4.4)	5 (35.7)	0.003[a]*
Osteoarthritis	5 (7.4)	4 (28.6)	0.042[a]*
Migraine	1 (1.5)	0	1.000[a]
Dyspepsia	3 (4.4)	0	1.000[a]
Back pain	2 (2.9)	0	1.000[a]
Lung disease	0	0	-
Kidney disease	2 (2.9)	2 (14.3)	0.133[a]
Cancer	3 (4.4)	0	1.000[a]
Dementia	0	1 (7.1)	0.171[a]
Others	25 (36.8)	5 (35.7)	0.941[b]

[a] Fisher's exact test [b] Pearson Chi-square
* Statistically significant ($p<0.05$)

The use of regular medication which had side effects with loss of appetite was compared between the normal nutrition group and the at risk of malnutrition group. Eight participants in total took regular medication which had side effects with loss of appetite. Although the percentage of participants in the at risk of malnutrition group taking these medications was higher than in the normal nutrition group (14.3%: 8.8%), the difference between the groups was not statistically significant (p>0.05).

Comparison of incidence of depression, insomnia and osteoarthritis between periodontal health status groups in the at risk of malnutrition group is shown in Table 7. In the periodontitis group, the percentages of subjects with depression (25%) and insomnia (37.5%) were higher than in the healthy gingiva/gingivitis group, but not significantly different (p>0.05). Interestingly, the incidence of participants in the periodontitis group with osteoarthritis (50%) was more markedly greater than in the healthy gingiva/gingivitis group (0%) but even in this case the difference was not significantly different (p=0.085).

Table 7 Comparison of depression, insomnia and osteoarthritis between healthy gingiva/gingivitis group and periodontitis group in at risk of malnutrition group.

Variables	Periodontal status: n (%)		p-value
	Healthy gingiva/ Gingivitis (n=6)	Periodontitis (n=8)	
Depression	0	2 (25.0)	0.473
Insomnia	2 (33.3)	3 (37.5)	1.000
Osteoarthritis	0	4 (50.0)	0.085

Fisher's exact test

Discussion

In the study population of 82 independently living elderly people (41 with periodontitis and 41 with gingival health or gingivitis), there was no prevalence of malnutrition (0%) and a low prevalence of at risk of malnutrition (17.1%), determined by the MNA score.[49] While there was a slightly higher prevalence of periodontitis in participants at risk of malnutrition (57.1%) compared to those with normal nutritional status (48.5%), this study did not find a statistically significant association between nutrition status and periodontal disease.

This study was designed based on the results obtained by Badawi et al.,[42] who reported a significant association between poor diet and periodontal disease. The results from this study were different from the Badawi study because of differences in the assessment tools used to detect malnutrition and differences in the study populations. This study used the MNA, which is designed to detect malnutrition risk by assessing body measurements, several questions related to general health, living arrangements and dietary intake. The Badawi study used the Healthy Eating Index (HEI), which is focused on dietary intake and measurement of diet quality. The MNA and HEI measure different things, which could lead to differences in study outcomes about the incidence of periodontal disease according to nutritional status between this study and Badawi's study. About the study populations, Badawi's study was carried out in a systematic random sample of healthy adults aged between 18–70, whereas this study was carried out only in elderly.

Periodontitis increases in extent and severity across a large proportion of the human population with aging.[29] The results from this study found that PI, GI, BOP, mean PD and mean CAL in the at risk of malnutrition group were higher than in the normal nutrition group, but the differences were not statistically significant. These findings are similar to the study reported by Akin et al.[56] They studied the CPI (Community Periodontal Index) in 295 non-edentulous patients and reported that they could not find any difference in CPI scores between the malnutrition/malnutrition risk and normal nutritional groups.

The findings from this study were not consistent with Mesas et al., who found advanced periodontitis is related to nutritional deficit in non-institutionalized older adults in Brazil.[57] In Mesas's study, 56 from-152 participants (36.8%) had advanced periodontitis. The criteria for advanced periodontitis in the Brazilian study was PPD ≥6 mm which is more severe periodontitis than in the current study (the presence of 4 or more teeth with 1 or more sites with PPD ≥4 mm and with clinical attachment loss ≥3 mm at the same site).

Therefore, the periodontal disease in Mesas's study may have more progression than in this study. When comparing the number of natural teeth between studies, this study had older adults with ≥20 teeth 77.94% in the normal nutrition group and 78.57% in the at risk of malnutrition group, which were higher percentages than in Mesas's study (16.7% in normal nutrition group and 15.5% in nutritional deficit group). The number of older adults in the nutritional deficit group in Mesas's study was higher than this study (21.7% vs 17.1%). These features of Mesas's study may have made it more likely to identify relationships and significant factors related to nutritional status between nutrition status and periodontitis than this study.

Knowledge from previous studies showed that older individuals exhibit increased susceptibilities to several autoimmune, infectious and inflammatory diseases, including periodontitis.[29] Periodontitis was a risk factor for future tooth loss among older adults.[58] The loss of periodontal supporting structures had negative effects on masticatory performance and quality of life.[23,59] In this study, the number of natural teeth, FTUs and chewing ability in the normal nutrition group was higher than in the at risk of malnutrition group although the difference was not statistically significant. Other studies have reported that dental status, number of tooth loss, number of natural teeth, functional tooth units (FTUs) and chewing ability were associated with nutritional deficiencies.[14-18] A previous study in Thailand reported that participants with malnutrition had significantly lower numbers of teeth, less functional tooth units and decreased chewing ability than those with normal nutrition .[14] Gil-Montoya et al also found that the perception of oral health status was significantly worse in the group with malnutrition/risk of malnutrition than in the group with normal nutrition.[60] Another study in 569 home-dwelling older adults concluded that older adults with fewer teeth or fewer pairs of natural teeth, especially posterior teeth, presented poorer nutritional status.[61] Another systematic review with meta-analysis reported significantly higher number of teeth present, number of pairs of teeth and FTUs in the normal nutrition group than in the risk of malnutrition/malnutrition group.[62]

Within the at risk of malnutrition group, the number of participants with periodontitis was higher than the number with healthy gingiva/gingivitis, although no significant difference was found. This may imply that older adults with periodontitis tend to be at risk of malnutrition. Thus, providing adequate dental care and disease prevention for the older population is important. Interdisciplinary and holistic treatment is also necessary.

Masticatory function was assessed by chewing tests and questionnaires or personal interviews. The chewing tests allowed the assessment of masticatory efficiency with some objectivity, whereas the questionnaires helped to evaluate a person's subjective response about chewing ability.[63] The test food could be various natural foods or artificial foods such as colour-changeable chewing gum which was a valid and reliable method.[64] In 2011, Samneing et al. developed the first reliable chewing ability questionnaire test.[14] Because this self-rated chewing ability test uses simple Thai foods that are commonly eaten in daily life and older adults find it easy to understand by viewing photos of food, this questionnaire was used for evaluating chewing ability in this study. The problem found when using this questionnaire was that the participants misunderstood the meaning of "do not eat" versus "cannot chew". Some participants answered the questionnaire with "cannot chew" but they meant "do not eat" so the interviewer had to explain the detail of the questionnaire intensively.

The MNA, used as the nutritional assessment in this study, was set up for simple and rapid evaluation of nutritional status and validated to provide a single, rapid assessment in elderly patients in clinics, hospitals and nursing homes.[49,65] MNA is easily carried out by health professionals to detect early risks of malnutrition.[4] Of the 82 participants in this study, only 14 (17.1%) participants were in the at risk of malnutrition group. Similar results were found in two previous studies in community-dwelling German older adults; the first reported 11% were at risk of malnutrition and 0% had malnutrition[66] and the second reported 15.1% at risk of malnutrition and 0% had malnutrition.[67] A prospective study in home-living Swedish older adults found 14.5% were

at risk of malnutrition at baseline.[68] All studies used MNA for nutritional status assessment and reported results similar to this study, although all studies were in different populations. Therefore, MNA can be used for rapid screening of nutritional status for the patients when malnutrition is suspected.

Considering the MNA questionnaire responses from the at risk of malnutrition group in this study, it was found that all participants in periodontitis group had low-moderate protein consumption and almost of them (87.5%) did not consume dairy products every day. Dairy products may represent a valuable dietary source of calcium due to their high calcium and nutrient contents, high absorptive rate, availability and relatively low cost.[69] As a result of aging, muscle mass can reduce and lead to an imbalance of muscle reinforcement and decomposition. Therefore the supplement of dairy products has been postulated to prevent further loss of lean mass, promote muscle accretion and enhanced function.[70] Furthermore, sugar and carbohydrate intake are associated with increased risk of dental caries and gingival bleeding.[41] Periodontal diseases may belong to the sugar-driven inflammatory diseases, similar to diabetes, obesity and cardiovascular disease.[71] High-sugar, high-saturated fat, low-polyols, low-fiber and low-polyunsaturated fat intake causes an increased risk of periodontal diseases. Conversely, low-sugar, high-fiber and high-omega-6 to omega-3 fatty acid ratio intake reduces the risk of periodontal diseases.[72] Therefore, healthy food consumption may help to reduce inflammation in periodontitis patients.

BMI is an index of weight-for-height that is commonly used to classify people as underweight, normal weight, overweight or obese.[73] In this study, the normal nutrition group had significantly higher BMI (23.7±2.8 kg/m^2) than the at risk of malnutrition group (21.3±3.3 kg/m^2, p=0.006). Bahat et al., reported that malnutrition and malnutrition risk rates were higher in the lower BMI groups.[74] Another study in geriatric outpatients also reported that patients with malnutrition had a lower BMI than patients with better nutritional status.[6]

This study showed that insomnia and osteoarthritis were significantly higher in the risk of malnutrition group than in the normal nutrition group. All participants with osteoarthritis in the risk of malnutrition group had periodontitis. The risk of malnutrition group also had higher incidence of depression than the normal nutrition group. Previous studies reported that the patients with malnutrition had more depressive symptoms and significantly higher incidence of osteoporosis than in normal nutrition group.[6] A study of 413 Turkish older adults found that malnutrition risk showed positive correlation with the incidence of insomnia and depression.[75] Another study in 2,327 patients also showed significant association between depression and poor nutritional status; however, the result presented that there was no significant association with osteoarthritis.[76] A prospective study in Sweden found that the most important findings predicting risk of malnutrition were high age, low self-perceived health and symptoms of depression.[68] A study in Korea found that severe periodontitis was positively and significantly associated with osteoarthritis in middle-aged and older adults with type 2 diabetes.[77] A study of 330 Thai community-dwelling older adults using multivariate analysis found that osteoarthritis is one of the factors significantly associated with nutritional risk (OR:2.49, 95% CI=1.14-5.48).[78]

Osteoarthritis is the most common degenerative joint disorder and the leading cause of adult disability, affecting one or several diarthrodial joints such as the hand, knee and hip joints.[79] Hand osteoarthritis is highly prevalent, and individuals with this condition frequently report symptoms of pain, functional limitations and frustration in undertaking daily physical activities.[80] Impaired hand function in older adults with this disease affected eating habit via difficulty in holding eating utensils and putting food or drink into the mouth. The quality and quantity of food intake will therefore be decreased, leading to malnutrition risk. In addition, the patient's capability to maintain adequate oral hygiene can be affected by reduced manual dexterity during routine toothbrushing and flossing. The recommendations for providing dental care to these patients include the use of an electric toothbrush, floss with handle and frequent dental appointment.[81] Furthermore, both periodontitis and

osteoarthritis are mediated by proinflammatory cytokines such as IL-6 and TNF-α with low-grade inflammation. Therefore, these inflammatory cytokines could be the link between periodontitis and malnutrition in older adults with osteoarthritis.

This study and previous studies suggest an association between insomnia, osteoarthritis and depression with risk of malnutrition. Older adults with these symptoms tend to have an association with periodontitis and malnutrition but this is still not clear. Thus, we would keep in mind that older adults with these symptoms may be at risk of malnutrition and further study is needed to answer these questions.

The digestive processes of food in the elderly are changed in various aspects i.e., poor chewing of hard foods, dry mouth, swallowing difficulty, lower gastric acid, decrease of digestive enzymes, decrease of gut movement and change in gut microbiota.[82] The interplay between gut microbiota and the host immune system appears highly relevant in the elderly. Alterations in the gut microbial population and changes in gut permeability may contribute directly to chronic low-grade infection (LGI). Inflammatory cytokines such as IL-1β, IL-6, T-helper 17-derived interleukin-17 (Th17-derived IL-17) and interleukin-22 (IL-22) are more specific and associated with the gut microbiota.[83] Thus, IL-1β and IL-6 could be the specific inflammatory cytokines that link between gut dysbiosis and periodontitis.

CKD, IBD and DM have all been linked to the association between periodontitis and malnutrition in the elderly via inflammatory processes. In this study, older adults with IBD could not participate and few older adults with CKD and DM participated in the study population. Only two participants with CKD and 2 participants with DM were in the risk of malnutrition group. A significant association between periodontitis and malnutrition in older adults with these diseases could not be found. In future, malnutrition in older adults with periodontitis and these chronic inflammatory diseases via inflammatory cytokines and dietary intake should be the subject of further investigation.

A limitation of this study was a lack of diversity of participants. Sixty four percent of participants had a higher education than secondary school thus the participants in this study had a good basic knowledge in health education which might have contributed to their high nutritional status. More participants may have been included in the malnutrition group if more participants with varied education level had been included in the study. In addition, this study was carried out in academic dental centres which are situated in city, therefore most of the participants had easy access to health information. Therefore, the results from participants in this study were representative of the population due to low diversity of educational level of participants. In addition, these results could not apply to participants in rural areas due to the differences in educational level and the chance to access the health information from the urban population.

In this study, a significant association between periodontitis and malnutrition in older adults could not be found and the significant factors which related to malnutrition in older adults with periodontitis could not be identified from this study. The high percentage of participants with normal nutritional status (82.9 %) made it more difficult for the study to detect an effect of nutritional status with high statistical confidence.

Further studies are needed for understanding these relationships in greater detail. A multi-centre study would allow a larger sample size and broader subject population. A controlled study with selection of "malnutrition" patients for comparison with a "normal" control group would increase the probability of significant outcomes compared to the cross-sectional design used in the current study. Assessment of nutrition status could be further investigated to identify the best measure of malnutrition. Malnutrition should be included in the inclusion criteria. The Barthel Index for Activities of Daily Living (ADL) and Thai Mental State Examination (TMSE) should not be used for inclusion criteria because they may tend to exclude the malnutrition group before participating in the research. These kinds of question are included in the MNA assessment. The impact of mental health on nutrition status should be considered in designing data collection and analysis.

Conclusion

In conclusion, the significant association between periodontitis and malnutrition in older adults was not found in this study. BMI was significantly higher in the normal nutrition group than in the at risk of malnutrition group. Although the number of natural teeth, FTUs, and chewing ability were higher in the normal nutrition group than in the at risk of malnutrition group, the differences were not significant. The periodontal parameters and the number of artificial teeth were lower in the normal nutrition group than in the at risk of malnutrition group; however, these differences were also not significant. Insomnia and osteoarthritis were significantly higher in the at risk of malnutrition group than in the normal nutrition group. The at risk of malnutrition group had a higher incidence of depression than the normal nutrition group, but this difference was also not significant.

Declaration of interest

The authors report no conflict of interest.

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การศึกษาความสัมพันธ์ระหว่างโรคปริทันต์กับภาวะทุพโภชนาการในผู้สูงอายุกลุ่มหนึ่งในประเทศไทย

กันย์สินี ชาตกิตติคุณวงศ์ กันยวัชร์ รัตนสุวรรณ***

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อหาความสัมพันธ์ระหว่างโรคปริทันต์กับภาวะทุพโภชนาการในผู้สูงอายุ รวมถึงศึกษาปัจจัยที่เกี่ยวข้องกับภาวะทุพโภชนการ การศึกษานี้เป็นการศึกษาแบบตัดขวางในอาสาสมัครอายุ ≥60 ปี ที่สามารถช่วยเหลือตนเองได้ โดยใช้แบบสอบถามในการเก็บข้อมูลทั่วไป การวัดขนาดของร่างกาย และการประเมินความสามารถในการเคี้ยวอาหารด้วยตนเอง ใช้แบบบันทึกการตรวจทางคลินิกเพื่อเก็บข้อมูลเกี่ยวกับสภาวะปริทันต์ จำนวนซี่ฟัน และจำนวนฟันคู่สบ ร่วมกับการประเมินภาวะโภชนาการ มีอาสาสมัครเข้าร่วม 82 คน แบ่งตามภาวะโภชนาการที่พบได้ 2 กลุ่ม คือ 1. กลุ่มภาวะโภชนาการปกติ (82.9%) และ 2. กลุ่มเสี่ยงต่อภาวะทุพโภชนาการ (17.1%) จากการศึกษาไม่พบความสัมพันธ์ระหว่างโรคปริทันต์กับภาวะทุพโภชนาการในผู้สูงอายุทางสถิติ (p=0.557) พบว่าปัจจัยเรื่องระดับการศึกษามีผลต่อภาวะโภชนาการอย่างมีนัยสำคัญทางสถิติ (p=0.009) และพบร้อยละของผู้สูงอายุที่เป็นโรคนอนไม่หลับและโรคข้อเสื่อมอยู่ในกลุ่มเสี่ยงต่อภาวะทุพโภชนาการมากกว่ากลุ่มภาวะโภชนาการปกติอย่างมีนัยสำคัญทางสถิติ (p=0.003 และ p=0.042) นอกจากนี้ยังพบว่าผู้สูงอายุที่เป็นโรคซึมเศร้าอยู่ในกลุ่มเสี่ยงต่อภาวะทุพโภชนาการมากกว่าผู้สูงอายุกลุ่มอื่น (14.3% : 1.5%) จากการศึกษานี้ไม่พบความสัมพันธ์ระหว่างโรคปริทันต์กับภาวะทุพโภชนาการในผู้สูงอายุ แต่พบความสัมพันธ์ระหว่างโรคนอนไม่หลับ โรคข้อเสื่อม และโรคซึมเศร้ากับความเสี่ยงต่อภาวะทุพโภชนาการในผู้สูงอายุ ดังนั้นผู้สูงอายุที่มีอาการในโรคดังกล่าวอาจมีความเสี่ยงต่อภาวะทุพโภชนาการ และควรมีการศึกษาเพิ่มเติมต่อไป

คำไขรหัส: *ภาวะทุพโภชนาการ/ผู้สูงอายุ/ โรคปริทันต์อักเสบ*

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