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ASSOCIATION OF DENTAL PROSTHETIC CONDITION WITH FOOD CONSUMPTION AND THE RISK OF MALNUTRITION AND FOLLOW-UP 4-YEAR MORTALITY RISK IN ELDERLY TAIWANESE

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Abstract: *Objective:* To determine the impact of dental prosthetic condition on food consumption, risk of malnutrition and follow-up 4-year mortality risk in elderly Taiwanese. *Design and setting:* Analyzing the data sets of the 1999 and 2003 "Survey of Health and Living Status of the Elderly in Taiwan", a longitudinal cohort study. *Participants:* A national probability sample of 2766 men and women 65 years of age or older. *Measurements:* Self-reported intake frequencies of major food categories, masticatory ability, food consumption, and the risk of malnutrition assessed with the Mini Nutritional Assessment (short-form) stratified by dental prosthetic condition. Cox regression was used to compare follow-up mortality risk. *Results:* Non-denture wearers and removable-denture wearers had poorer masticatory ability and greater nutritional risk and consumed fruits and vegetable less often compared to fixed-denture wearers. Removable-denture wearers also had lower self-perceived nutritional status and BMI compared to fixed-denture wearers. Survival analysis showed that non-denture wearers and removable-denture wearers had lower follow-up 4-year survival. Cox regression analysis showed that removable-denture wearers had increased follow-up 4-year mortality risk compared to fixed-denture wearers adjusted for sociodemographic, lifestyle and health-related factors. *Conclusions:* Based on data of a national sample of a longitudinal cohort study, dental prosthetic condition is a significant factor of nutritional health in the elderly. It can affect food pattern and the risk of malnutrition and mortality of elderly persons. Dental care should be an important part of geriatric health promotion program and fixed-denture is a preferred choice over removable-denture.

Key words: Denture, removable-denture, fixed-denture, nutrient intake, nutritional status.

Introduction

Aging is often associated with loss of natural teeth. Poor dental prosthetic condition may impact systemic health and increase mortality risk through impairing nutritional, physical and mental statuses (1, 2). Thus, dental prosthetic condition is important for maintaining masticatory function or swallowing ability to prevent the development of malnutrition in the elderly. Prosthetic dental treatment can often be done with fixed or removable dentures. However, elderly who have lost many natural teeth often have to settle for removable-dentures because of inadequate number of healthy natural teeth to serve as anchors. Removable-dentures usually cost less than fixed-dentures and are worn by a relatively large number of elderly Taiwanese. Dental prosthetic condition has long been suggested to affect food choice, nutrient intake and nutritional status of elderly persons (3-9). Marshall et al. (10) have further confirmed the nutrient intake-lowering effect of ill-fitted denture by analyzing 3-day nutrient intakes of Iowans aged 79 years or older. Reviews by Ritchie et al. (11) and Moynihan et al. (12) also have concluded that tooth loss affects dietary quality and nutrient intake in a manner that may increase the risk for several systemic diseases.

Dental prosthetic condition has also long been shown to be associated with mortality risk of community-living elderly (13, 14). However, to our knowledge the association of dental prosthetic condition with mortality risk has not been observed with a national sample.

Griep et al. (15) employed the Mini Nutritional Assessment (MNA) to evaluate the risk of malnutrition in elderly living in retirement homes and found that the nutritional status graded with the MNA was correlated with dental prosthetic conditions. We have also shown that a Taiwanese-specific (content-equivalent) version of the MNA is suitable for assessing the nutritional status and follow-up mortality risk of the general elderly population in Taiwan. (16-18) Hence, the present study was aimed to evaluate the possible impact of various dental prosthetic conditions on food consumption, nutritional risk status (assessed with the MNA) and the follow-up 4-year mortality risk in a national sample of elderly Taiwanese.

Methods

This study analyzed data of the "Survey of Health and Living Status of the Elderly in Taiwan" (SHLSET), a population-based longitudinal cohort study conducted by the Bureau of Health Promotion of Taiwan for gaining an understanding of the role of socioeconomic, environmental, lifestyle and healthcare factors on health, well-being and quality of life of older Taiwanese (19). The study employed a multi-stage equal probability sampling process based on records of the national household registration. The first stage
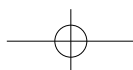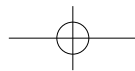
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involved a selection of 56 of the 331 (excluding 30 mountainous areas) administrative units (townships) of Taiwan. The second stage involved systematic and proportionate-to-size random selection of blocks (lins) from selected townships to serve as primary sampling units (PSU). The third stage was systematic random selection of two eligible respondents from each of the selected lins. This process selected 4049 men and women 60 years or older to serve the initial sample in 1989.

A second sample of 2462 subjects, 50-66 years, was selected with the same method and added to the cohort to extend the age range to 50 years in 1996. Subjects in the cohort were interviewed every 3 to 4 years and a total of 6 rounds of interviews (in 1989, 1993, 1996, 1999, 2003 and 2007) were completed. The 1999 survey contained a special component for assessing dietary intake/nutritional status and the 2003 survey was the latest one available for analysis, served as baseline and end-point of the present investigation, respectively. The protocol of SHLSET was reviewed and approved by government-appointed representatives and the study was conducted according to ethical standards set forth in the Helsinki Declaration (20). All participants were given informed consent and subjects' anonymity was preserved at all times.

In each survey, trained interviewers conducted in-home, face-to-face interviews to elicit sociodemographic, anthropometric, health and healthcare-related information on each subject. Persons with severe disabilities or persistent ill health were completed with proxy interview. The present analysis included only those (2766) who were 65 years of age or older by the end of 1999. In the survey, subjects were specifically asked whether he/she wore any denture and whether it was a removable- or fixed-denture. Thus, in the current study subjects were classified into three groups according to their dental prosthetic conditions: wearing fixed-denture, removable-denture (partial or whole) or no denture. All subjects were also asked to assess their masticatory ability according to a 5-level Likert scale. All dental status-related data were self-reports and were visually confirmed by the interviewers. Mortality data were taken from records maintained by the survey, and confirmed with records of the National Health Insurance Program, and the National Household Registration. Response rates were 90.1% and 91.6% for 1999 and 2003 surveys, respectively. (19)

Food choices and dietary supplement use were computed from intake frequencies of the major food categories recorded during the 1999 interview. The nutritional status of each subject was graded with a content-equivalent version (adopted Taiwanese-specific anthropometric cut-points) of the short-form Mini Nutritional Assessment (MNA-SF-T) (18) based on data recorded in the survey. Differences in the distribution of body mass index (BMI), self-assessed health status, masticatory ability, food intake, self-perceived malnutrition and nutritional status were statistically analyzed with Chi-square test. Log Rank test was performed to determine the significance of differences of follow-up 4-year survival curves. Cox regression analysis (adjusted for sex, age, years of formal education, living arrangement, cigarette-smoking, betel-nut chewing, cognitive status (MMSE score), functional disability (ADL), diabetes mellitus, stroke and self-perceived nutritional status) was also performed to determine the relative mortality risk. All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS version 14.0. Chicago, IL). Statistical significance was accepted at $\alpha = 0.05$.
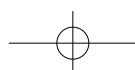
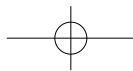**Table 1**
Characteristics of 2766 subjects (%)

Parameter	Men (n=1527)	Women (n=1239)
Years of formal education		
0	25.7[a]	64.5
1-6	41.3	27.1
≥7	32.9	8.4
Ethnicity		
Fukienese	50.4	73.3
Others	49.6	26.7
Current smokers	37.4	4.7
Alcohol-drinking[b]	33.9	7.0
Betel-nut chewing	4.5	4.3
Self-reported chronic diseases		
Heart disease	18.9	26.7
Diabetes mellitus	13.8	18.7
Stroke	7.9	7.2
Cancer	3.0	3.2
Cognitive impairment (MMSE status)		
Mild cognitive impairment	19.0	31.2
Severe cognitive impairment	4.0	23.0
No. of ADL dependency		
0	90.3	84.6
1	1.6	2.5
2	1.4	2.1
≥3	6.7	10.8
Dental status		
65-75 years (n)[c]	(n=910)	(n=664)
Removable denture	33.3	46.9
Fixed dental prosthesis	36.4	35.2
No restoration	30.3	17.9
≥75 years (n)[c]	(n=617)	(n=575)
Removable denture	47.5	57.3
Fixed dental prosthesis	22.0	23.0
No restoration	30.5	19.7

ADL=Activities of Daily Living; MMSE=Mini Mental State Examination. a. Values are % within gender; b. ≥1 time/wk; c. Distributions of the two age groups are significantly different from each other (p<0.001).

Results

Roughly 60% of men and 54% of women were 65-74 years old. The rest were over 75 years of age. Over 1/3 of men but only a few percentage of women smoked or drank alcohol; 4.5% of men and 4.3% of women were betel-nut chewers (a lifestyle vice of some Southeastern Asians who chew the seed of Areca palm often wrapped in betel leaves for their effects as a mild stimulant, causing a mild hot sensation in the body and slightly heightened alertness). Nineteen percent of men and 27% of women self-reported having heart disease, 14% of men and 19% of women had diabetes, 7-8% had stroke and 3% had cancer; 23% of man and 54% of women had cognitive impairments; 10% of men and 15% of women had at least one

functional dependency. Significantly greater proportions of older persons especially women wore removable-dentures. Roughly 30% of men and 18-20% of women wore no dentures (Table 1).

Significantly greater proportions of fixed-denture wearers and non-denture wearers than removable-denture wearers consumed three or more bowls of rice per day. A significantly greater proportion of non-denture wearers consumed dairy and fruits less frequently than fixed-denture wearers or removable-denture wearers. Significantly greater proportions of non-denture wearers or removable-denture wearers consumed vegetables less frequently than fixed-denture wearers (Table 2). No significant differences in the consumption frequency of meat, fish, egg or legume were observed. (Data on sweets and beverages were not available in the data set).

Table 2

Distribution (N, %) of food intake frequencies of 2766 elderly Taiwanese stratified by dental prosthetic status

Food types & times/wk	Fixed (N=833)	Removable (N=1237)	None (N=696)	p
Cereal (rice/wheat) consumption (Q-CA15b,				
≥3	556 (68.4)[a]	791 (64.2)[b]	495 (72.1)[a]	0.002
≤2	262 (31.6)	441 (35.8)	192 (27.9)	
Meat (all kinds)				0.596
≥3	458 (55.0)	673 (54.5)	393 (56.9)	
≤2	374 (45.0)	562 (45.5)	298 (43.1)	
Fish				0.281
≥3	559 (67.3)	829 (67.1)	441 (63.9)	
≤2	271 (32.7)	406 (32.9)	249 (36.1)	
Sea foods				0.382
≥3	86 (10.4)	145 (11.7)	87 (12.6)	
≤2	744 (89.6)	1090 (88.3)	604 (87.4)	
Eggs				0.401
≥3	331 (39.8)	516 (41.8)	299 (43.2)	
≤2	500 (60.2)	718 (58.2)	393 (56.8)	
Dairy				<0.001
≥3	429 (51.6)[a]	666 (54.0)[a]	304 (44.1)[b]	
≤2	403 (48.4)	567 (46.0)	385 (55.9)	
Legume				0.571
≥3	368 (44.3)	518 (41.9)	295 (42.7)	
≤2	463 (55.7)	717 (58.1)	396 (57.3)	
Vegetable				<0.001
≥3	809 (97.5)[a]	1177 (95.2)[b]	648 (93.6)[b]	
≤2	21 (2.5)	59 (4.8)	44 (6.4)	
Fruits				0.002
≥3	635 (76.3)[a]	919 (74.4)[a]	474 (68.7)[b]	
≤2	197 (23.7)	317 (25.6)	216 (31.3)	

a., b., c.Values carrying different superscripts represent significantly different from each other on the basis of Chi-square test (p<0.05). Consumption data of sweets and beverages were not available in the data set.

No differences in appetite status were observed among the three groups but greater proportions of non-denture wearers or removable-denture wearers lost more than 3 kg body weight during the past 6 months or were underweight (Table 3). Overall, significantly greater proportions of removable-denture wearers (25.7%) or non-denture wearers (26%) were at high

risk of malnutrition compared to fixed-denture wearers (20.6%).
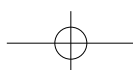
Table 3

Scoring patterns and nutritional statuses of 2766 subjects rated with the short-form Mini Nutritional Assessment according to dental prosthetic status

Item (item score)	Score	Fixed (N=833)	Removable (N=1237)	None (N=696)
A. Appetite status over past 3 m (2)				
Severely poor	0	76 (9.1)	134 (10.8)	78 (11.2)
Moderately poor	1	0 (0.0)	2 (0.2)	3 (0.4)
No loss of appetite	2	757 (90.9)	1101 (89.0)	615 (88.4)
B. Weight loss during the last 3 m (3)				
Weight loss >3kg	0	111 (13.3)	212 (17.1)	119 (17.1)
Does not know	1	2 (0.2)	2 (0.2)	4 (0.6)
Weight loss 1-3kg	2	0 (0)	0 (0)	0 (0)
No weight change	3	720 (86.5)	1023 (82.7)	573 (82.3)
C. Mobility (2)				
Bed or wheelchair-bound	0	13 (1.6)	30 (2.4)	38 (5.4)
Can get out of bed/chair but can't go out	1	47 (6.8)	40 (4.8)	63 (5.1)
Can move around	2	780 (93.6)	1144 (92.5)	611 (87.8)
D. Have suffered psychological stress (2)				
Two or more times	0	92 (11.0)	132 (10.6)	59 (8.5)
One time only	1	74 (8.9)	91 (7.4)	71 (10.2)
No	2	667 (80.1)	1014 (82.0)	566 (81.3)
E. Neuropsychological problems (2)				
Severe dementia or depression	0	2 (0.2)	1 (0.1)	0 (0)
Mild dementia	1	9 (1.1)	24 (2.0)	20 (2.9)
No psychological problem	2	813 (98.7)	1197 (97.9)	670 (97.1)
F. Body Mass Index (kg/m²)				
<17	0	15 (1.8)	40 (3.2)	25 (3.6)
17-19	1	47 (5.6)	117 (9.5)	57 (8.2)
19-21	2	136 (16.4)	233 (18.8)	115 (16.5)
≥21	3	635 (76.2)	847 (68.5)	499 (71.7)
Distribution of nutritional score				
Malnourished	≤7	25 (3.0)[a]	53 (4.3)[b]	39 (5.7)[b]
At risk of malnutrition	8-11	145 (17.6)	262 (21.4)	140 (20.3)
Normal	≥12	654 (79.4)	907 (74.3)	511 (74.1)

a., b., c. Values (or distributions) not carrying the same superscript are significantly different from each other on the basis of Chi-square test (p<0.05).

Fixed-denture wearers had the best masticatory ability while non-denture wearers had the worst ability among the three types of dental prostheses (Table 4). A significantly greater proportion of non-denture wearers had self-perceived malnutrition compared to fixed-denture wearers. Greater proportions of removable-denture wearers also had self-perceived malnutrition, lower BMI and lower MNA scores compared to fixed-denture wearers. However, there were no significant differences in self-rated appetite status among the three groups. Among the removable-denture wearers, 89.3% wore it most of the time but 10.7% wore it only during eating.

According to Kaplan-Meier survival analysis non-denture wearers or removable-denture wearers had significantly greater follow-up 4-year mortality risk compared to fixed-denture wearers (both p<0.001). However, according to Cox regression significant difference in mortality risk existed only between fixed-denture wearers and removable-denture wearers adjusted for sociodemographic, lifestyle and health-related variables. The hazard ratio and (95% confidence interval) were 1 for
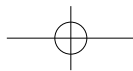
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fixed-denture wearers; 1.30 (1.01-1.66) (p<0.05) for non-denture wearers and 1.10 (0.88-1.38) (p=0.42) for removable-denture wearers (Fig. 1).

Table 4

Distribution (N, %) of nutrition- and health-related statuses of 2766 elderly Taiwanese according to dental prostheses conditions

Parameters	Fixed (N=833)	Removable (N=1237)	None (N=696)	p
Self-assessed masticatory ability				<0.001
Good or very good	471 (56.6)[a]	515 (42.4)[b]	260 (37.5)[c]	
Acceptable	197 (23.6)	365 (30.0)	156 (22.5)	
Poor or very poor	165 (19.8)	336 (27.6)	278 (40.1)	
Self-assessed food intake status				
65-74 y				0.365
Significantly poorer	44 (7.8)	61 (10.0)	39 (9.9)	
No change or better	521 (92.2)	551 (90.0)	355 (90.1)	
≥75y				0.843
Significantly poorer	32 (11.9)	73 (11.7)	39 (13.0)	
No change or better	236 (88.1)	550 (88.3)	260 (87.0)	
Living status				0.400
Alone	98 (11.8)	115 (9.3)	71 (10.2)	
With family	723 (86.8)	1096 (88.8)	611 (87.8)	
Institutions	12 (1.4)	24 (1.9)	14 (2.0)	
Self-assessed food intake by living status				
Alone				0.499
Poorer	14 (14.3)	15 (13.0)	6 (8.5)	
No change/better	84 (85.7)	100 (87.0)	65 (91.5)	
With family				0.166
Poorer	62 (8.6)	114 (10.4)	71 (11.7)	
No change/better	661 (91.4)	980 (89.6)	537 (88.3)	
In institutions				0.155
Poorer	0 (0)	5 (20.8)	1 (7.1)	
No change/better	12 (100)	19 (79.2)	13 (92.9)	
Self-perceived malnutrition				0.036
Yes	56 (6.8)[a]	122 (10.1)[b]	62 (9.2)[ab]	
No	764 (93.2)	1083 (89.9)	614 (90.8)	
Body Mass Index (kg/m2)				0.002
<21	198 (23.8)[a]	390 (31.5)[b]	197 (28.3)[ab]	
21-27	531 (63.7)	693 (56.0)	423 (60.8)	
≥27	104 (12.5)	154 (12.5)	76 (10.9)	
Nutritional risk status by MNA-SF				0.019
Malnourished (≤7)	25 (3.0)[a]	53 (4.3)[b]	39 (5.7)[b]	
At risk (8-11)	145 (17.6)	262 (21.4)	140 (20.3)	
Normal (≥12)	654 (79.4)	907 (74.3)	511 (74.1)	
Frequency of wearing (n, %)				
All the time	---	1051 (89.3)	---	
During eating only	---	62 (5.3)	---	
Rarely	---	64 (5.4)	---	

a., b., c. Values (or distributions) not carrying the same superscript are significantly different from each other on the basis of Chi-square test (p<0.05).

Discussion

Results of the present study suggest that dental prosthetic condition can have an impact on masticatory ability, food selection, overall nutritional status, and follow-up mortality risk of the elderly. Significantly greater proportions of non-denture wearers or removable-denture wearers than fixed-denture wearers reported poor chewing ability, self-perceived malnutrition, low BMI or greater risk of malnutrition (according to MNA-SF). These findings generally support

observations made in Western populations. Appollonio et al. (14) observed that denture wearers had lower intake of micronutrients and denture (removable) use was indirectly associated with mortality risk. Papas et al. (3) observed that poor dietary quality was associated with self-reported partial or full denture. Nowjack-Raymer et al. (21) observed that denture wearers had lower intakes of hard foods such as carrots and tossed salads compared to the fully dentate. Liedberg et al. (7) observed that elderly with removable-dentures had reduced chewing ability and were less able to mix and shape gum bolus or consume hard foods, but, there was no clear impact on overall nutrient intake or health status. Marshall et al. (10) analyzed the 3-day nutrient intakes of Iowans aged 79 years or older and confirmed that mean daily nutrient intakes were significantly lower in subjects who had fewer natural or functional teeth and ill-fitting mandibular dentures than in subjects who had more teeth or did not have these problems.

Figure 1

Follow-up 4-year unadjusted (A) and adjusted (B) survival curves for elderly Taiwanese according to dental prosthesis conditions. (A) On an unadjusted basis, Log Rank test showed that the survival for non-denture wearers or removable-denture wearers were significantly different from fixed-denture wearers (both p<0.001). The difference between removable-denture wearers and non-wearers was not significant (p=0.294) (left figure). (B) Cox regression adjusted for sex, age, years of formal education, living arrangement, cigarette-smoking, betel-nut chewing, cognitive status (MMSE score), functional disability (ADL), diabetes mellitus, stroke and self-perceived nutritional status showed a significant difference in 4-year survival only between removable-denture wearers and fixed-denture wearers. Hazard ratio and (95% confidence interval) were 1 for fixed-denture wearers (reference), 1.31 (1.02-1.69, p<0.05) for removable-denture wearers and 1.18 (0.88-1.58, p>0.05) for non-denture wearers.
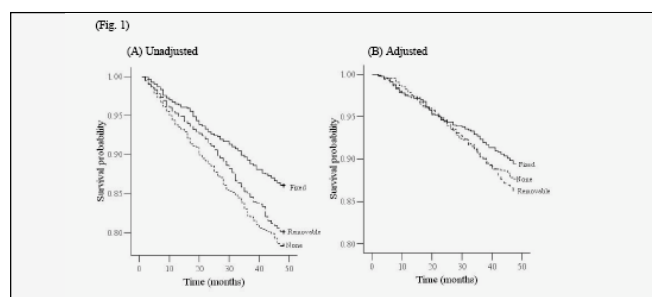
Technical quality of removable-denture is a factor associated with impaired chewing ability and nutrient intakes. The NHANES-III study showed that 60% of removable-dentures had technical quality problems (22). Soini et al. (23) showed that malnutrition increased consistently with the increasing number of oral health problems (including chewing problems, swallowing difficulties, pain in mouth and xerostomia) and
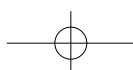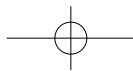
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Wostmann et al. (24) showed that repair or replacement of poor dentures improved chewing ability of the elderly. Technical quality is also known to be an issue in Taiwanese who wear removable-dentures. In the present study approximately 10% of removable-denture wearers wear them only during eating; presumably due to technical quality problems. Lu et al. (25) reported that nearly 40% of Taiwanese elderly had poor or very poor denture functioning status. However, the technical quality of denture was not available in the data set.

Results of the present study show that dental prosthetic condition is a significant factor impacting long-term mortality risk of the elderly. On an unadjusted basis, both removable-denture wearers and non-denture wearers have higher mortality risk than fixed-denture wearers. However, when controlled for sociodemographic, lifestyle and health-related variables, only non-denture wearers had significantly increased mortality risk compared to fixed-denture wearers. Dental prosthetic condition has been observed to be associated with mortality risk in community-living elderly and in edentulous institutionalized elderly (2, 13, 14). The current study has further shown that dental prosthetic condition can impact not only the risk of malnutrition but also the risk of mortality in the elderly at the population level.

Roughly 25% of the cohort in the present study self-reported wearing no denture at all. Because the survey included no oral/dental examination, it was not possible to analyze the dental status of this group. But based on the fact that 40% of the group self-rated poor or very poor chewing ability comparing to 20% of those who wore fixed-dentures, it is reasonable to assume that a large proportion of those wearing no dentures had poor dental conditions. Nutritional risk-screening with the MNA-SF indicated increased risk of malnutrition in those who wore no dentures. It has been shown that poor dental condition can impact on systemic health and increase the risk of physical disability and mental impairment through affecting nutrient intakes (2, 11). However, it is obvious that in addition to dental prosthetic conditions, socioeconomic factors could also contribute to the increased risk of malnutrition or mortality in elderly who have poor dental prosthetic conditions. Because of cost, a greater proportion of people with lower socioeconomic status choose removable dentures. Elderly with lower socioeconomic status also have inferior diet (limited variety) and consume less fruits and dairy products than elderly having higher status (12). Dairy is a major source of dietary calcium and high quality protein whereas fruits are an important source of micronutrients and antioxidants. Elderly who have inadequate intake of these foods may compromise immune competency and have increased risk of systemic diseases (11) and even mortality. It is also of interest to note that a significantly greater proportion of elderly wearing removable dentures were underweight (BMI<21) compared to fixed-denture wearers in the present study. Underweight and unplanned weight loss has been observed to be associated with increased mortality risk in elderly Taiwanese. (26)

This study has some limitations. (a) Data were self-reports. Self-reports are generally reliable but some errors are unavoidable, especially without examination. (b) For those having dental prostheses, no information was available regarding whether one had partial or full denture or the status of dental prostheses. (c) For those wearing no denture, no further information was available regarding their dental statuses. (d) No data on the technical quality of denture or number of natural teeth were available. (e) The data set contained no biochemical markers to confirm the nutritional status of subjects. (f) The food frequency questionnaire was a cross-sectional survey that could not reflect longitudinal food intake changes. Additionally, industrialization of the society also has had a great impact on food pattern of the citizens. The traditional non-refined high grain and high vegetable plant-based diet has given way to a more refined and meat-based diet but the impact could not be evaluated.

In conclusion, results derived from this population-representative cohort study indicate that dental prosthetic condition can impact chewing ability, food choice, risk of malnutrition and mortality risk of older Taiwanese. Elderly who have poor dental condition or are wearing removable-dentures have inferior chewing ability, poorer food choices and greater nutritional and mortality risks compared to elderly wearing fixed-dentures. Removable-dentures, although able to restore some chewing ability, are generally less ideal than fixed-dentures. These findings should provide useful data and information to health planners in making health promotion policies for the elderly.

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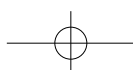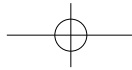
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