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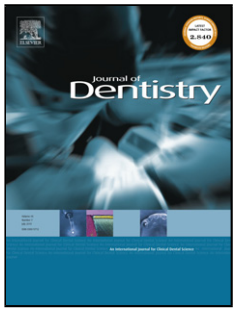

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Authors: Piyada Gaewkhiew, Wael Sabbah, Eduardo Bernabé

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Does Tooth Loss affect Dietary Intake and Nutritional Status? A Systematic Review of Longitudinal Studies

Piyada Gaewkhiew[1,2], Wael Sabbah[1], Eduardo Bernabé[1]

[1] Division of Population and Patient Health, King's College London Dental Institute at Guy's, King's College and St. Thomas' Hospital, London, United Kingdom

[2] Department of Community Dentistry, Faculty of Dentistry, Bangkok, Mahidol University, Thailand

Corresponding author:

Piyada Gaewkhiew

Division of Population and Patient Health

King's College London Dental Institute

Denmark Hill Campus

Bessemer Road, London SE5 9RS, UK

Tel: +44 (0)79-2327-6531

DOES TOOTH LOSS AFFECT DIETARY INTAKE AND NUTRITIONAL STATUS? A SYSTEMATIC REVIEW OF LONGITUDINAL STUDIES

ABSTRACT

Introduction/Objective: A systematic review was conducted to explore whether tooth loss affects dietary intake and nutritional status among adults.

Keywords: Tooth loss; Dental status; Dietary intake; Nutritional Status; Nutritional assessment; Systematic review

Data: Longitudinal studies of population-based or clinical samples of adults exploring the effect of tooth loss on food/dietary/nutrient intake and/or nutritional status were included for consideration. The risk of bias was assessed using the Newcastle-Ottawa Scale for cohort studies.

Sources: A search strategy was designed to find published studies on MEDLINE, EMBASE and LILACS up to March 2017.

Study Selection: Eight longitudinal studies in 4 countries (United States, Japan, Australia and Brazil) were included. Five of the six studies investigating the association between tooth loss and dietary intake showed significant results. The only consistent association, as reported in 2 studies, was for greater (self-reported) tooth loss and smaller reductions in dietary cholesterol. Three of the 4 studies investigating the association between tooth loss and nutritional status showed significant results. However, most results were contradicting. The quality of the evidence was weak.

Conclusion: There is at present no strong evidence on the effect of tooth loss on diet and nutrition, with inconsistent results among the few studies identified. Additional high-quality longitudinal studies should address the limitations of previous studies identified in this review.

Abbreviations and acronyms:

Keywords: Tooth loss, Oral Health, Food, Nutritional Status, Nutritional assessment, Review

ADL: Activities of daily living

BMI: body mass index

DVS: Dietary variety score

FFQ: Food Frequency Questionnaire

FTU: Functional tooth unit(s)

MNA: mini nutritional assessment

NOS: Newcastle-Ottawa Quality Assessment Scale

REE: resting energy expenditure

USA: United States of America

WC: Waist circumference

INTRODUCTION

Diet is an important component of leading a healthy life as it has a role in the aetiology, and thus prevention, of many chronic conditions such as obesity, cardiovascular disease, diabetes and cancer among other chronic conditions [1,2]. Tooth loss and nutritional intake are intricately connected [3]. The oral cavity is not only the entryway for nutrient intake but the primary function of teeth is mastication [4]. Tooth loss reduces masticatory function and chewing ability, which in turn can limit food choices and variety in the diet [5-7]. For these reasons, dietary intake has been regarded as an intermediate in the pathway between tooth retention and a number of diet-related chronic diseases [8-10].

Given these claims, it is not surprising to find a few reviews on the interrelationship between tooth loss, diet and nutritional status [11-14]. However, they are not without limitations. Earlier reviews did not follow a systematic procedure for the identification and synthesis of studies [11-14]. Later reviews have been more systematic in their approach to review the available literature but have had a limited scope looking at older adults [11], free-living older adults [12,14] or papers published very recently [14]; missed some important longitudinal studies [12]; included evidence from cross-sectional studies [11-14]; or did not assess the quality of the included studies [11]. The latter point is important since confounding by participants' socioeconomic status and health status needs to be addressed in observational studies [11-14]. Without addressing these limitations, robust conclusions on the association between tooth loss and nutrition cannot be reached. The aim of this study was to systematically review longitudinal evidence on whether tooth loss affects dietary intake and nutritional status among adults. Although a poor diet, especially one low in calcium [15] and fibre [16], may be a risk factor for tooth loss, we are interested in how tooth loss may influence dietary intake, and subsequently, nutritional status, given the increasing interest in tooth loss as a risk factor for various chronic diseases and mortality.

METHODS

This systematic review followed the Meta-Analysis of Observational Studies in Epidemiology (MOOSE) recommendations [17,18]. The review protocol was registered in PROSPERO (Registration number CRD42017065361).

Criteria for considering studies for this review

Broad criteria were predefined to select articles for inclusion, following the PICO format. Only longitudinal/panel studies were included as they provide the strongest observational evidence. Case-

control, cross-sectional, case report/series and expert opinions were excluded. Participants were adults aged 18 years or above, irrespective of recruitment setting (community-dwelling, nursing/care homes, hospitals) and health status (generally healthy or with one or more morbidities). The exposure was tooth loss measured at least once during the duration of the study (baseline assessment) through self-reports or clinical examination. The outcome measures were dietary/food/nutrient intake (measured as total energy intake or specific nutrient intake from questionnaires, recalls, blood samples, etc.) and nutritional status (measured as weight loss, body mass index, anthropometric measurements, etc.).

Study selection and data extraction

Three electronic databases (MEDLINE via PubMed, EMBASE via Ovid and LILACS via BIREME) were searched for published literature up to March 2017 using a combination of Medical Subject Headings (MeSH) terms and text words around three main topics: the exposure (tooth loss) and the outcomes (nutrient intake or nutritional status). These were combined with methodological filters for longitudinal studies specific for each database. Search terms were chosen based on the team expertise and previous related reviews. No language restrictions were applied. Search strategies are shown in Supplemental file 1.

All references retrieved were managed in bibliographic software EndNote X7 (Clarivate Analytics, New York, United States). Duplicated articles were excluded at this stage. Two reviewers (PG and EB) independently and in duplicate screened the titles and abstracts of all identified publications against the eligibility criteria for inclusion. The full-text of publications were sought if at least one of the reviewers considered the study as potentially meeting the inclusion criteria. The final decision about whether a study met the inclusion criteria was made based on the full-text and after discussion between reviewers. The grey literature was searched by looking for relevant material in OpenGrey repository, Google Scholar and searching the internet using the pre-set text words as well as searching all relevant reference lists of identified articles and related reviews.

A master file was created in excel listing all studies retrieved and including their title, authors, journal, publication year and reason for exclusion (Supplemental file 2). For eligible studies, the two reviewers additionally extracted information on study design, participants' characteristics (sample size, age range and country), length of follow-up, attrition rate, exposure variables, outcome measurements,

covariates/confounders, data analysis and main findings. Disagreements were resolved through discussion.

Risk of bias assessment

Included studies were assessed for risk of bias using the Newcastle-Ottawa Quality Assessment Scale (NOS) [19]. The NOS evaluates three domains: selection (4 items), comparability (1 item) and outcome (3 items). A study could be given one star for each item under selection and outcome and two stars under comparability. For selection, a star was given when the exposed cohort was truly or somewhat representative of exposed adults in the community, when the non-exposed cohort was drawn from the same community as the exposed cohort, when the exposure (tooth loss) was ascertained through clinical examinations, and when the outcome of interest was measured both at baseline and follow-up. For comparability, a star was given when the study controlled for socio-demographic characteristics (sex, age and any socioeconomic position indicator) during the design or analysis, and it was given two stars when it additionally controlled for participants' health status (chronic conditions, comorbidities, activities of daily living and the like). For outcome, one star was given when the assessment of outcome was independent/blinded or through record linkage, when the follow-up period was long enough for changes in outcomes to occur, and when all participants were accounted for during follow-up or those lost to follow-up were unlikely to introduce bias (<20% attrition rate and description provided of those lost). A good quality scored required 3-4 stars in selection domain AND 1-2 stars in comparability domain AND 2-3 stars in outcome domain; a fair quality study required 2 stars in selection domain AND 1-2 stars in comparability domain AND 2-3 stars in outcome domain; and a poor quality study 0-1 stars in selection domain OR 0 stars in comparability domain OR 0-1 stars in outcome domain [19].

Data synthesis

A meta-analysis of the findings (i.e. forest and funnel plots) was not feasible given the high level of heterogeneity found across studies. Instead, we opted for a narrative synthesis of the results [20]. To that end, we created tables summarising the key methodological characteristics of all included studies and the methodological quality assessment of the studies based on NOS.

RESULTS

A flow chart of the screening and selection of studies is shown in Figure 1. Of the 2232 unique citations retrieved, 2133 articles were excluded after screening titles and abstracts as clearly irrelevant. The full

text of 99 articles was retrieved to check eligibility and 89 articles were subsequently removed as not meeting the inclusion criteria. The major cause for exclusion was using a cross-sectional design (n=43). Therefore, a total of 10 reports in 8 cohorts were included in this systematic review.

Table 1 summarises the characteristics of the included studies. Two Japanese studies [21,22] and two Unites States (US) studies [3,23] used data from the same cohorts, the Niigata Study and the Health Professionals' Follow-up Study, respectively. They were considered as different analyses of their respective cohorts. Thus, we summarised findings based on 8 original studies; 4 in the US, 2 in Japan, 1 in Australia and 1 in Brazil. Five studies were subsets of population-based cohorts whereas the three remaining studies recruited male health professionals [3,23], female nurses [24] and patients admitted to hospital [25]. The follow-up times of all studies varied from a few days to 10 years. Sample sizes ranged from 134 to 59,467 participants. Participants' age varied from 30 to 65+ years.

Measurement of exposure varied considerably between studies. Tooth loss was measured as number of teeth [25,26], functional units [22,26], chewing surfaces [26], a combination of teeth present and occlusal supports [21], edentulism [27], need for dental prosthesis [25,27] or self-reported measures such as edentulism [27,28], number of teeth lost [3,23,24] and chewing ability [26,29]. Only 3 studies measured tooth loss over time, either clinically [21] or using self-reports [3,23,29]. Great variation was also noted in the measurement of outcomes. Only 1 study measured both nutrient intake and nutritional status [25]; 4 studies reported data on nutrient intake [3,21-24,29] and 3 studies reported data on markers of nutritional status [26-28]. Dietary assessment methods included food frequency questionnaires (FFQ) [3,24,29], dietary recalls [22], visual estimation of plate waste [25] and number of items eaten [21]. No study measured concentrations of nutrients from biological samples such as blood (plasma or serum) or urine. Nutritional status was only assessed via anthropometric measurements, such as weight [26-28], waist circumference [27] and Body Mass Index (BMI) [25]. One study used the Mini Nutritional Assessment (MNA) which measures both food intake and markers of nutritional status [25]. No study used biomarkers (such as albumin) to indicate nutritional status.

Effect of tooth retention on food/nutrient intake

Of the 5 studies reporting the association between tooth loss and nutrient intake, 4 showed some significant associations, although results were inconsistent across measures of tooth loss and food intake. Two FFQ-based studies [3,23,24] showed the number of teeth lost (self-reported) was

associated with smaller reductions in cholesterol (Table 3). These studies [3,24] also showed that greater tooth loss was associated with smaller increases in consumption of dietary fibre (Table 3). In the US Health Professionals' Follow-up Study, this association was not seen after 4 years of follow-up [23], but it only emerged after 8 years [3]. On the other contrary, a dietary recall-based study showed that fewer functional tooth units (FTUs) were associated with greater decline in dietary fibre [22]. Declines in potassium were found among adults with fewer FTUs in one study [22] and women who lost 1-4 teeth –although not among those who had lost 5+ teeth– [24] (Table 3). The number of teeth lost was also associated with smaller reductions in consumption of fruit and vegetables [3,23], saturated and trans fats [24] and greater reduction in consumption of polyunsaturated fats [3,23]. Having more teeth and occlusal supports was associated with more food items eaten, although results were unadjusted [21], which agrees with a further study where deteriorating chewing ability was associated with greater decline in dietary variety [29]. The one study reporting no significant findings had the shortest follow-up (days) and smallest sample [25].

Effect of tooth retention on nutritional status

Of the 4 studies reporting the association between tooth retention and nutritional status, 3 studies showed some significant associations. However, results were contradicting. Two studies [26,27] showed that clinically determined edentulism was associated with weight loss, although not with weight gain [27], whereas another study [28] showed that self-reported edentulism was associated with weight gain but not weight loss (Table 3). Edentulism was also found to be associated with greater odds of waist circumference loss [27]. The study with no significant results had the smallest sample, shortest follow-up and measured BMI and MNA at follow-up only [25].

Quality of included studies

The quality assessment is presented in Table 2. Seven out of 8 studies were scored as poor, while the remaining study was qualified as fair. In terms of selection, 5 studies were representative of the general adult population [21,22,26-29], all studies selected the non-exposed cohort from the same population as the exposed, only 3 studies used clinical measures of tooth loss [21,22,26,27], and all but one [25] measured change in outcomes (food/nutrient intake or nutritional status). In terms of comparability, 5 studies adjusted for participants' sociodemographic factors and health status [22,26-29] and the remaining 3 studies only adjusted for sociodemographic factors [3,23-25]. In addition, only two of the

studies on nutrient intake included adjustments for total energy intake [3,23,24]. As for the outcomes, all studies but one, that lasted for 3 to 7 days [25], had an appropriate duration of follow-up (i.e. between 1 and 10 years). Moreover, only 2 studies had attrition rates lower than 20% although the impact of losses to follow-up on the results was not reported in those studies [25,28]. Finally, no studies provided a description of blind assessment of the outcomes.

DISCUSSION

This systematic review identified 8 published relevant longitudinal studies in the US, Australia, Japan and Brazil. Four of the 5 studies investigating the association between tooth loss and nutrient intake showed some significant results while 3 of the 4 studies investigating the association between tooth loss and nutritional status showed significant results. However, most results were contradicting. The quality of the evidence on the effect of tooth loss on diet and nutritional status was weak.

For tooth loss and nutrient intake, the three most common associations reported in the literature were those for dietary cholesterol, fibre and potassium. On one hand, greater tooth loss (albeit self-reported) was associated with smaller reductions in cholesterol in two FFQ-based studies [3,23,24]. As teeth are incrementally lost, people may choose easy to chew food items which are high in sugars and fat [5,28]. It is worth noticing that dietary cholesterol from FFQs do not distinguish between low- and high-density lipoprotein cholesterol (LDL and HDL, respectively). Hence, a study measuring blood levels of total, HDL and LDL cholesterol could help clarify this finding. On the other hand, contradicting results were found for fibre intake and potassium. While two studies showed smaller increases in dietary fibre in adults who have lost teeth [23,24], another study reported greater reductions in dietary fibre in adults with $\leq$5 FTU) [22]. Although having $\leq$5 FTU was also associated with decline in potassium intake [22], another study only found declines in potassium for women who lost 1-4 teeth but not for those who lost 5+ teeth compared to women with no tooth loss [24]. One of the inherited limitations of current methods for nutrient intake assessment is that they do not account for how nutrients are consumed. People with few or no teeth may consume these nutrients as soft diet or liquids, which would explain the non-significant findings across most nutrients assessed in the studies identified.

For tooth loss and nutritional status, the most common association reported in the literature was that for weight changes, although inconsistent findings were found. Tooth loss was associated with weight loss in 2 studies [26,27], but also with weight gain in another study [28]. Food avoidance because of

tooth loss, and decreasing chewing ability, could make people lose weight. On the other hand, weight gain could result from extraction of loose teeth or diseased teeth (with associated pain and infection). Once these teeth are removed, people could eat better and possibly gain weight [6,30].

This review highlights the need for further longitudinal studies including clinical measures of tooth loss (the number of teeth but also the distribution and functioning of those units) along with dental pain and tooth mobility, a blinded assessment of outcome and strategies to reduce the impact of attrition on the results. Further studies in alternative settings would also enhance the generalisability of findings. Studies in low-and-middle-income countries would be highly relevant, especially where traditional diets (as opposed to Western diets) are still in place. Further studies would also benefit from multidisciplinary collaboration with nutritionists/dieticians, especially with regards to nutrient intake assessment. Stronger evidence on this important research area is still needed to inform policy and practice. For the time being, we believe it is important to highlight the relevance of delivering comprehensive care to adults and especially senior adults, in multidisciplinary teams including physicians, dentists and dieticians/nutritionists who should be supported by appropriate referral system. Dentists could screen for malnutrition in their daily practice whereas doctors and dieticians should consider dental status as a factor associated with various diseases and refer patients to dentists to improve their dental status.

Some limitations of this review should be considered. First, the high variability in methods used to measure exposures and outcomes precluded any pooling of results, and therefore, a meta-analysis could not be performed. This was in addition to the role of confounders in the hypothesised associations as there was heterogeneity in the extent of covariates controlled for during statistical analysis. Second, for practical reasons we limited our search strategy to three electronic databases and did not fully search for unpublished studies (i.e. grey literature), decisions which may have affected our ability to identify all relevant studies. Third, no formal assessment of publication bias could be carried out for this review. We identified 22 reports when searching the grey literature, but none of them were included in the end. It is thus possible that we were unable to retrieve all unpublished studies. Selective publication may have arisen from cohort studies with available dental and diet/nutrition data, which were analysed but never reported because findings were non-significant or in the unexpected direction.

CONCLUSION

This systematic review indicates there is weak evidence on the association of tooth loss with nutrient intake and nutritional status. Inconsistent findings were reported across the 8 longitudinal studies identified. The only consistent association, as reported in two studies, was for greater self-reported tooth loss and small decreases in dietary cholesterol. Additional high-quality longitudinal studies should address the limitations of previous studies identified in this review.

CONFLICT OF INTEREST

There is no conflict of interests to be reported.

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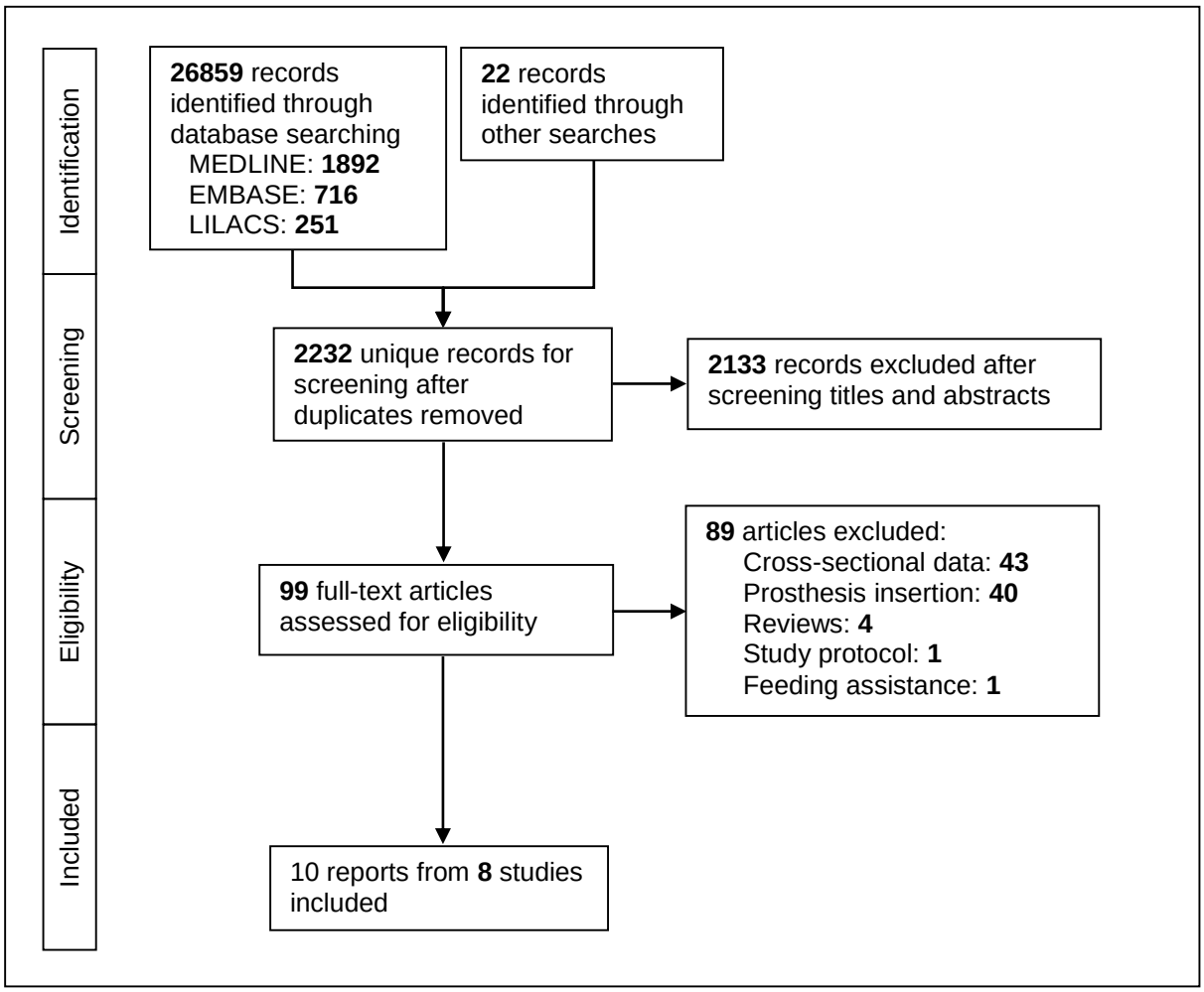

Figure 1. Flowchart of the selection of studies for the review

Table 1. Longitudinal studies on the association of tooth retention with nutrient intake and nutritional status in adults

Authors (year)	**Study design**	**Study sample**	**Exposure**	**Outcomes**	**Covariates**	**Main findings**
Sato et al. (2016); Iwasaki et al. (2016)	Panel study with 10-year follow-up (1998 to 2008)	600 community-dwelling adults aged 70 years (Niigata Study, Japan); 41.8% attrition (n=251)	Change in dentition status: 10+ occlusal supports (Zone A), 5-9 occlusal supports (Zone B), <4 occlusal supports or 11+ remaining teeth (Zone C), and ≤10 remaining teeth (Zone C)	Number of chewable items (0-8): peanuts, pickled daikon radish, hard-baked rice crackers, beefsteak, vinegar octopus, scallions, dried squid and raw squid at baseline and follow-up	None	The number of food items that could be chewed decreased in subjects who remained in Zone A, those who changed from Zone B to Zone D, and those who changed from Zone B to Zone C.
	Longitudinal study with 5-year follow-up (2003 to 2008)	370 free-living adults aged 75 years (Niigata Study, Japan); 21% attrition (n=79)	FTU (pair of opposing natural or prosthetic teeth excluding third molars) in 2003	Total energy, protein, carbohydrates, fat, sodium, potassium, calcium, vitamins A, D, E, B6, B12, folate and dietary fibre from a 1-month brief-type diet history questionnaire at baseline and follow-up	Sex, education, income, smoking status, ADL, BMI, comorbidities	Greater decline in protein, sodium, potassium, calcium, dietary fibre and vitamins A and E intake as well as in vegetable and meat intake in those with impaired dentition than in those without impaired dentition.
de Andrade et al. (2014)	Longitudinal study with 4-year follow	1,413 community-dwelling adults aged 60+ years	Edentulism (no/yes) and need for dental prostheses (no/yes) in 2006	Changes in weight and WC from 2006 to 2010: stable (within 5% of 2006 values),	Sex, age, education, number of self-reported chronic	The odds of weight and WC loss were higher among edentate than dentate adults.

	up (2006-2010)	(Survey on Health, Well-being and Aging, Brazil); 30% attrition rate (n=423)		loss (decrease of 5% or more) and gain (increase of 5% or more)	diseases, baseline weight and WC, smoking status and physical activity	Edentulism was not associated with weight or WC gain. The need for dental prostheses was not associated with change in weight or WC
Mudge et al. (2011)	Longitudinal study with 2-to-6-day follow-up	134 patients aged 65+ years admitted to general medical wards in 2007/08 (Australia); no attrition rate	Poor dentition defined as missing teeth or ill-fitting or absent dentures by a dietitian	BMI, MNA, and inadequate energy (energy intake less than REE) from visual estimation of plate waste on a single day between days 3 and 7 of admission	Sex, age, residence, diagnosis, co-morbidities, medications and hospital ward	There was no association between poor dentition or nutritional status and inadequacy energy intake
Kwon et al. (2006)	Panel study with 8-year follow-up (1992-2000)	738 free-living adults aged 65+ years (Longitudinal Interdisciplinary Study on Aging, Japan); 43.5% attrition rate (n=321)	Self-reported chewing ability in 1992 (good/poor) and changes in chewing ability from 1992 to 2000 (always good, deteriorating, improving and always poor)	DVS (0-10, counting items eaten: meat, eggs, fish and shellfish, milk, dark-coloured vegetables, soybean products, potatoes, fruits, seaweeds, and fats and oils) from a 1-week FFQ. Decline was defined as a change in DVS	Sex, age, education, baseline functional capacity and DVS, change in spouse status and new chronic diseases during the study period	Adults with deteriorating self-perceived chewing ability had greater odds of experiencing a decline in dietary variety

				<=-2 points from 1992 to 2000		
Hung et al. (2005)	Longitudinal with 4-year follow-up (1990-1994)	59,467 female nurses aged 46-71 years, with 11+ remaining teeth and who completed FFQ in 1990 and 1994 were analysed; (Nurses' Health Study, USA); attrition was not reported	Self-reported number of teeth lost in the past 2 years (0, 1-4, 5+) in 1992	Changes in total energy, saturated, trans, mono- and poly-unsaturated fats, cholesterol, fibre, carotene, beta-carotene, vitamins C, E, B6, B12, folate, potassium, flavonoids, fruits and vegetables from 1-year semi-quantitative FFQ over 4 years	Total energy intake, age, physical activity and smoking status	Women who lost 5+ teeth had smaller reduction in intake of monounsaturated fats whereas women with 1-4 teeth lost had smaller reductions in saturated fat, trans fat and cholesterol, and smaller increases in fibre, carotene, vitamin C, and potassium, and greater reduction in folate than women with no tooth loss
Lee et al. (2004)	Longitudinal with 1-year follow-up (1997-1998)	3068 free-living adults aged 70-79 years (Health ABC Study, USA); 11.7% attrition rate (n=362)	Self-reported edentulism in 1997	Weight change from baseline to follow-up (loss: loss of >5%, stable: ±5% weight change, gain: gain of >5% of baseline body weight)	Sex, age, race, education, living alone, study site and family income	Edentate adults were more likely to have weight gains than were dentate adults, even after controlling for confounders
Hung et al.	Panel study	31,813 male	Self-reported number of teeth	Total calories, carbohydrate,	Total energy	Adults who lost 5+ teeth had smaller

(2003); Joshipura et al. (1996)	with 8-year follow-up (1986-1994)	health professionals aged 40-75 years with 11+ teeth at baseline and answered FFQ (Health Professionals' Follow-up Study, USA); attrition was not reported	lost (0, 1-4 and 5+) during the 8-year period	fats, dietary fibre, vitamin, fruits and vegetables from 1-year semi-quantitative FFQ in 1986 and 1994	intake and baseline dietary intake, age, number of teeth, smoking, physical activity and profession	reduction in consumption of dietary cholesterol and vitamin B12, greater reduction in consumption of polyunsaturated fat and smaller increase in consumption of dietary fibre and whole fruit than those who had lost no teeth
	Panel study with 4-year follow-up (1986-1990)	49,501 male health professionals aged 40-80 years with 17+ teeth at baseline and who answered FFQ (Health Professionals' Follow-up Study, USA);	Self-reported number of teeth lost (no tooth loss versus 5+ teeth lost over 4 years	Dietary fibre, crude fibre, carotene, cholesterol, saturated fat, fruits servings (excluding juices) and vegetables (servings) from 1-year semi-quantitative FFQ in 1986 and 1990	Baseline intake of nutrient, age, health profession, smoking status and exercise	Participants who lost 5+ teeth reduced their cholesterol intake by 11 milligrams compared to those with no tooth loss

		37.9% attrition (n=18,763)				
Ritchie et al. (2000)	Longitudinal study with 1-year follow-up	979 community-dwelling adults aged 70-96 years (New England Elders Dental Study, USA); 25.5% attrition (n=250).	Self-reported chewing difficulty and clinical measures: dentate status, number of teeth, functional units and chewing surfaces (number of adjacent functional units)	Weight loss using 2 thresholds (≥4% and ≥10% of baseline weight)	Sex, income, advanced age (≥80 years), >2 chronic conditions, dependence in 1+ daily activities and baseline weight	Edentulousness was an independent risk factor for weight loss after adjusting for sex, income, age and baseline weight

ADL: Activities of daily living; BMI: body mass index; DVS: Dietary variety score; FFQ: Food Frequency Questionnaire; FTU: Functional tooth units, MNA: mini nutritional assessment; REE: resting energy expenditure; USA: United States of America; WC: Waist circumference

Table 2. Methodological assessment of included studies using the Newcastle-Ottawa Scales (NOS) with converting scales

NOS items	Sato et al. (2016); Iwasaki et al. (2016)	de Andrade et al. (2014)	Mudge et al. (2011)	Kwon et al. (2006)	Hung et al. (2005); Joshipura et al. (1996)	Lee et al. (2004)	Hung et al. (2003)	Ritchie et al. (2000)
Representativeness of the exposed	*	*		*		*		*
Selection of the non-exposed	*	*	*	*	*	*	*	*
Ascertainment of exposure	*	*						*
Change in outcome[a]	*	*		*	*	*	*	*
Comparability	**	**	*	**	*	**	*	**
Assessment of outcome								
Duration of follow-up	*	*		*	*	*	*	*
Adequacy of follow-up			*			*		
Overall quality assessment	*Poor*	*Poor*	*Poor*	*Poor*	*Poor*	*Fair*	*Poor*	*Poor*

[a] This item was modified to identify studies that looked at change in nutritional intake or status, not to judge whether the outcome of interest was present at start of study (incidence studies)

Table 3. Results for specific nutrients and nutritional status indicators where at least 2 longitudinal studies reported the same outcomes.

Outcome	Author (year)	Results	Notes
Cholesterol (mg)	Joshipura et al. (1996); Hung et al. (2003)	0 teeth lost in 4 years (n=30459): -29.3 (0.69)[a] 5+ teeth lost in 4 years (n=279): -11.2 (5.02)[a]	Only for men with 17+ teeth at baseline. Reported as mean change (SE) in energy-adjusted nutrient intake over 4 years adjusted for baseline dietary intake, age, smoking status, exercise and profession
		0 teeth lost in 8 years (n=24921): -47.8[a,b] 1-4 teeth lost in 8 years (n=5992): -43.6[a] 5+ teeth lost in 8 years (n=900): -36.7[b]	Only for men with 11+ teeth at baseline. Reported as mean change in daily intake over 8 years adjusted for change in total energy intake and for baseline dietary intake, age, number of teeth, smoking status, physical activity and profession

	Hung et al. (2005)	0 teeth lost in 4 years (n=50,686): -16.9[a,b] 1-4 teeth lost in 4 years (n=8526): -15.1[a] 5+ teeth lost in 4 years (n=255): -7.5[b]	Only for women with 11+ teeth in 1992. Reported as mean change in dietary intake over 4 years adjusted for baseline dietary intake, age, physical activity, BMI and smoking
Fibre (g)	Joshipura et al. (1996); Hung et al. (2003)	0 teeth lost in 4 years (n=30459): 0.14 (0.01) 5+ teeth lost in 4 years (n=279): 0.15 (0.09)	Only for men with 17+ teeth at baseline. Reported as mean change in energy-adjusted nutrient intake over 4 years adjusted for baseline dietary intake, age, smoking status, exercise and profession
		0 teeth lost in 8 years (n=24921): 1.69[a] 1-4 teeth lost in 8 years (n=5992): 1.53 5+ teeth lost in 8 years (n=900): 1.16[a]	Only for men with 11+ teeth at baseline. Reported as mean change in daily intake over 8 years adjusted for change in total energy intake and for baseline dietary intake, age, number of teeth, smoking status, physical activity and profession
	Hung et al. (2005)	0 teeth lost in 2 years (n=50,686): 0.85[a] 1-4 teeth lost in 2 years (n=8526): 0.66[a] 5+ teeth lost in 2 years (n=255): 0.59	Only for women with 11+ teeth in 1992. Reported as mean change in dietary intake over 4 years adjusted for baseline dietary intake, age, physical activity, BMI and smoking
	Iwasaki et al. (2016)	FTU>5 (n=225): -4.2 FTU≤5 (n=61): -10.4 Difference: -6.2 (-12.3 to -0.1)	Reported as mean change (95%CI) in energy-adjusted nutrient intake over 5 years adjusted for sex, education, income, smoking status, ADL, BMI and comorbidities
Potassium (mg)	Hung et al. (2005)	0 teeth lost in 2 years (n=50,686): 219[a] 1-4 teeth lost in 2 years (n=8526): 208[a] 5+ teeth lost in 2 years (n=255): 204	Only for women with 11+ teeth in 1992. Reported as mean change in dietary intake over 4 years adjusted for baseline dietary intake, age, physical activity, BMI and smoking
	Iwasaki et al. (2016)	FTU>5 (n=225): -3.0 FTU≤5 (n=61): -9.3 Difference: -6.3 (-11.9 to -0.7)	Reported as mean change (95%CI) in energy-adjusted nutrient intake over 5 years adjusted for sex, education, income, smoking status, ADL, BMI and comorbidities
Weight (kg)	de Andrade et al. (2014)	5% weight loss versus stable Dentate (326): reference group Edentate (n=472): 2.11 (1.35-3.30) 5% weight gain versus stable Dentate (n=326): reference group Edentate (n=472): 0.87 (0.61-1.24)	Reported as OR (95%CI) for weight loss/gain in edentate compared to dentate adults, adjusted for baseline weight, age, sex, education, number of chronic diseases, need for dental prostheses and physical activity
	Lee et al. (2004)	5% weight loss over 1 year Dentate (n=1883): reference group Edentate (n=493): Not significant 5% weight gain over 1 year Dentate (n=1883): reference group	Reported as OR (95%CI) for weight loss/gain in edentate compared to dentate adults, adjusted for confounders (although the full list was not mentioned)

	Edentate (n=493): 1.73 (1.17-2.57)	
Ritchie et al. (2000)	4% weight loss Dentate (n=361): reference group Edentate (n=202): 1.63 (1.09-2.43) 10% weight loss Dentate (n=361): reference group Edentate (n=202): 2.03 (1.05-3.96)	Reported as OR (95%CI) for 4% and 10% weight loss after 1 year in edentate compared to dentate adults, adjusted for sex, age, income, baseline weight, more than two diagnosis and dependency in one or more activities of daily living

Letters in superscripts indicate groups that were significantly different
ADL: activities of daily living; BMI: Body mass index; CI: confidence interval; OR: odds ratio; SE: Standard error