# Oral Health and Nutrition in Older People

**Angus W. G. Walls, BDS, PhD, FDSRCS; Jimmy G. Steele, BDS, PhD, FDSRCPS; Aubrey Sheiham, BDS, PhD; Wagner Marcenes, BDS, MSc, PhD; Paula J. Moynihan, BDS, PhD, SurSRD, RPHNutr, FRSA**

**Abstract**

*The theoretical link between foods choice and masticatory efficiency has long been established. Recent evidence has confirmed this association, demonstrating a progressive alteration in food choice with decreasing numbers of teeth, with the greatest effect being among those who are edentulous. This altered food selection results in significant differences in the hematological status for some key nutrients in the one study in which this association was investigated. This paper summarizes some of the literature relevant to diet as a risk factor for systemic disease and identifies areas where altered food choice as a consequence of reduced masticatory efficiency might be placing individuals at increased risk of life-threatening conditions, such as atherosclerosis and cancer. [J Public Health Dent 2000;60(4):304-7]*

*Key Words: oral health, aging, diet, nutrition, general health.*

Chewing of food is important in the initiation of food digestion. It serves to comminute foods so that a bolus can be formed and swallowed. This process of breaking up food and converting it into a bolus to be swallowed is associated with the release of tasteants from the food, enhancing our enjoyment of the things we eat.

Because of the importance of chewing in the digestion of foods, it is reasonable to assume that the health status of the mouth might influence diet and nutrition. The numbers and distribution of teeth will influence the ease of chewing, particularly the presence of complete dentures. Chewing with conventionally retained dentures can be likened to an oral juggling act where the actions of the oral musculature and the forces of adhesion and cohesion hold the prostheses in place. The food itself has a profound destabilizing influence in this process, as forces are applied eccentrically to the dentures unless the bolus can be manipulated such that chewing occurs simultaneously on the right and left sides.

The purpose of this paper is to explore the evidence linking masticatory efficiency with foods choice and dietary limitation and the health risks that may be associated with such limitation.

## Masticatory Efficiency

The ability to break down foods into controlled lumps by chewing to permit swallowing is usually assessed by measuring the size of test food samples that have been chewed for a specific number of chewing cycles by study participants. The test food is expectorated and the comminuted food analyzed using a sieving method or, more recently, using image analysis techniques.

Testing consistently has demonstrated reduced efficiency in chewing with decreasing numbers of teeth, with teeth and removable partial dentures compared with a similar number of natural teeth and with complete dentures compared with a natural dentition (1-5). Aging alone has little effect on chewing efficiency, although the literature suggests some reduction in oral motor function as people get older, probably relating to altered muscle bulk (6,7).

## Masticatory Efficiency and Digestion

In the 1950s Farrell showed that chewing ability has no influence on digestion of food consumed in a modern diet. He had young healthy volunteers swallow muslin bags containing samples of unchewed, partially chewed and fully chewed foods. The bags were retrieved after passage through the bowel and foods analyzed for the extent of digestion. He found that the quality of digestion was independent of the extent by which the food had been chewed, but was dependent on the food type (8,9).

While informative, the relevance of Farrell's work to an older population is unclear because similar methods have not been used in the aged. Profound changes occur in the bowel with aging, including reductions in the rate of gastric motility and atrophy of the villii on the walls of the bowel. These changes influence the ability of an older person to digest and absorb foods.

## Masticatory Efficiency and Food Choice

While it may be the case that digestion per se is not influenced by mastication, compelling evidence supports food choice being affected by our ability to chew. As masticatory efficiency declines, people report increasing difficulty chewing foods and choosing not to eat foods that are difficult to chew. This avoidance is of particular importance for those foods that could be regarded as more difficult to chew, such as raw carrot, nuts, fibrous vegetables, and some fruits. People with fewer teeth become handicapped by their dentition and as a consequence may suffer impaired intakes of some key nutrients. One area of particular concern is the level of nonstarch poly-

Send correspondence and reprint requests to Dr. Walls, Dental School, Framlington Place, Newcastle upon Tyne, England NE2 4BW. Drs. Steele and Moynihan are also affiliated with the Dental School, Newcastle upon Tyne. Drs. Sheiham and Macenes are with the Department of Epidemiology and Dental Public Health, University College London. Paper presented as part of the satellite symposium "Successful Aging through Oral Health," Vancouver Island, British Columbia, March 14–16, 1999, organized by the Geriatric Oral Research Group of the International Association for Dental Research.

**TABLE 1**
**Comparison of Key Nutrient Intakes from the National Diet and Nutrition Survey and the VA Longitudinal Dental Survey [Numbers in brackets are Recommended Daily Allowances]**

| | Edentate | | Compromised | | Intact | |
|---|---|---|---|---|---|---|
| Nutrients | NDNS* | VADLS† | NDNS* | VADLS† | NDNS* | VADLS† |
| Base | 287 | 76 | 131 | 224 | 123 | 114 |
| Energy (kcal) | 1,583 | 1,677 | 1,700 | 1,795 | 1,842 | 1,894 |
| Protein (g) [63 g/d] | 60 | 68 | 66 | 74 | 71 | 80 |
| Fat (g) | 64 | 52 | 67 | 53 | 67 | 55 |
| Nonstarch polysaccharides (g) [25 g/d) | 11 | 16 | 13 | 19 | 16 | 21 |
| Calcium (mg) [800 mg/day] | 722 | 689 | 825 | 677 | 884 | 773 |
| Vitamin A (μg) [800 μg/d] | 1,036 | 1,297 | 1,374 | 1,490 | 1,268 | 1,756 |
| Vitamin C (mg) [60 mg/d] | 60 | 127 | 82 | 146 | 83 | 156 |
| Niacin (mg) [18 mg/d] | 27 | 34 | 33 | 28 | 32 | 32 |
| Vitamin E (mg) [10 mg/d] | 8 | 7 | 10 | 7 | 12 | 10 |

*National Diet and Nutrition Survey (UK), Ref. 15.
†VA Longitudinal Dental Survey, Ref. 14

saccharides (dietary fiber) intake, which is markedly reduced in older people compared with dietary reference values (4,10-14). In addition to declines in nutrient intake, increases in intakes of saturated fats, cholesterol, and calories are reported in older people as the number of teeth decline (14).

Recent data from both the United Kingdom and the United States confirm these associations between tooth loss status and food selection (14,15). Summaries of nutrient intake and biochemical markers of nutritional status from these two studies are provided in Tables 1 and 2. The observed associations are independent of the effects of age, sex, regional variation within a country, or socioeconomic group. The correlations between the biochemical data from the UK study and oral health status are the first of their type to be presented in the literature.

The effect of masticatory efficiency on food selection is likely to be compounded by food preparation. A person with reduced chewing efficiency may overprepare (e.g., removing the skin from fruits and vegetables) or overcook fresh foods in an effort to make consumption practical. A broad range of nutrients are affected by these practices, including foodstuffs that are thought to be important for cancer prevention (e.g., nonstarch polysaccharides or dietary fiber) and for cellular defense and combating the effects of aging (e.g., the antioxidant micronutrients vitamins C and E).

**TABLE 2**
**Plasma Concentrations of 3 Antioxidant Vitamins from the National Diet and Nutrition Survey (UK) [Ref 15]**

| | Dentate ($n$=254) | | Edentate ($n$=287) | |
|---|---|---|---|---|
| Plasma (μmol/l) | Mean | Median | Mean | Median |
| Ascorbate (vitamin C) | 49.1 | 48.7 | 39.4 | 40.1 |
| Retinol | 2.3 | 2.21 | 2.09 | 2.03 |
| Alpha-tocopherol | 38.6 | 36.9 | 37.0 | 36.1 |

## Dietary Fiber and Fruit and Vegetable Consumption

A number of papers recently have related oral health to systemic health, most notably to atherosclerotic disease and pneumonia in debilitated subjects. The prime focus for these papers is the role of periodontal pathogens and their associated circulating inflammatory markers in the initiation and progression of the formation of atherosclerotic plaques and thence disease (16-19). A significant body of evidence also associates dietary imbalance with a variety of systemic illnesses.

Reduction in dietary fiber and in fruits and vegetables consumption is associated with increased risk of cardiovascular disease (20-23). The mechanisms for this interaction have not been clarified fully, but probably relate both to the lipid-lowering capabilities of soluble fiber (24), as well as the effects of antioxidants from fruits and vegetables. Strong associations have been found between increased fruit and vegetable intake and reduced risk of esophageal, gastric, and colorectal cancer. In addition, some data link fruit and vegetable consumption to prostate, cervical, pancreatic, and bladder malignancy (25-28).

## Micronutrients

A large number of dietary components form an essential part of the cellular defense mechanisms against oxidative damage to DNA. These antioxidants include the trace elements selenium, zinc, and manganese; vitamins A, C, and E; and other plant-derived micronutrients, for example, betacarotene, luteine, lycopene, and plant flavenoids. The importance of these compounds in normal function is increasingly becoming apparent.

Links have been demonstrated between vitamin C and both excess win-

ter mortality in older people and cardiovascular disease and stroke (29-32). Evidence also links vitamin C and other antioxidant vitamins to cataract formation (33-35). In addition, vitamin E and lycopene intakes have been linked to cardiovascular disease risk (36-39).

The data relating micronutrients to risk of malignancy are less clearcut than for these other diseases. A number of studies show positive associations between intake of antioxidants and a variety of malignancies. However, a similar number demonstrate no association.

Intervention studies with micronutrient supplementation have been notably unsuccessful at reducing the risk of either cancer or of cardiovascular disease. Indeed one major intervention trial of betacarotene supplementation in the prevention of lung cancer was stopped before its anticipated termination date because the rate of development of cancers was greater in the test (supplemented) group than the controls (40-42). Possible explanations for this result include the following: (1) the doses used may not be adequate or may have been too great; (2) antioxidants may have a long-term effect and the short-term studies that have been undertaken to date may not have been able to show any effects as a consequence; or (3) these antioxidants might simply be markers that we can measure of a dietary pattern that equates to a healthy lifestyle—replacing a single component of the system arbitrarily would therefore have little effect.

## General Nutritional Status

In addition to the associations outlined for specific disease risk in this paper, general malnourishment is a considerable problem in older people, particularly for those who are admitted to the hospital. People who are malnourished have poorer outcomes in terms of their care, and remain in the hospital for longer than those who are adequately nourished. Reported chewing ability has been linked to these problems (43-46).

## Conclusions

Oral health status is intimately linked to food selection and preparation. These in turn influence dietary adequacy, nutritional status, and general health status. Might it be that edentulous people are at greater risk of dying because of their dietary preferences? Simple dietary supplements may have only a limited benefit in these circumstances because of the complex nature of foods and yet to be identified protective elements within them. Individuals with a compromised dentition will need a more radical change in food selection, preparation, or both. Changing long-standing dietary habits in older people is difficult, but needs to be addressed. It will require specific and carefully designed dietary interventions at an appropriate stage of care.

## References


1. Gunne HJ. Masticatory efficiency and dental state. A comparison between two methods. Acta Odont Scand 1985;43:139-46.
2. van der Bilt A, van der Glas HW, Mowlana F, Heath MR. A comparison between sieving and optical scanning for the determination of particle size distributions obtained by mastication in man. Arch Oral Biol 1993;38:159-62.
3. Mowlana F, Heath MR, van der Bilt A, van der Glas HW. Assessment of chewing efficiency: a comparison of particle size distribution determined using optical scanning and sieving of almonds. J Oral Rehabil 1994;21:545-51.
4. Feldman RS, Kapur KK, Alman JE, Chauncey HH. Aging and mastication: changes in performance and in the swallowing threshold with natural dentition. J Am Geriatr Soc 1980;28:97-103.
5. Akeel R, Nilner M, Nilner K. Masticatory efficiency in individuals with natural dentition. Swed Dent J 1992;16:191-8.
6. Newton JP, Yemm R, Abel RW, Menhinick S. Changes in human jaw muscles with age and dental state. Gerodontology 1993;10:16-22.
7. Baum B, Bodner L. Aging and oral motor function: evidence for altered function among older persons. J Dent Res 1983; 62:2-6.
8. Farrell JH. The effect of mastication on the digestion of food. Br Dent J 1956;100: 149-55.
9. Farrell JH. Partial dentures in the restoration of masticatory efficiency. Dent Pract Dent Rec 1957;7:375-9.
10. Yurkstas A, Emerson W. Dietary selections of persons with natural and artificial teeth. J Prosthet Dent 1964;14:695-7.
11. Chauncey HH, Muench ME, Kapur KK, Wayler AH. The effect of the loss of teeth on diet and nutrition. Int Dent J 1984;34: 98-104.
12. Moynihan PJ, Snow S, Jepson NJ, Butler TJ. Intake of nonstarch polysaccharide (dietary fiber) in edentulous and dentate persons: an observational study. Br Dent J 1994;177:243-7.
13. Joshipura KJ, Rimm EB, Douglass CW, Trichopoulos D, Ascherio A, Willett WC. Poor oral health and coronary heart disease. J Dent Res 1996;75:1631-6.
14. Krall E, Hayes C, Garcia R. How dentition status and masticatory function affect nutrient intake. J Am Dent Assoc 1998;129:1261-9.
15. Steele JG, Sheiham A, Marcenes W, Walls AWG. National diet and nutrition survey: people aged 65 years or over. Vol. 2. Report of the oral health survey. London: Her Majesty's Stationery Office, 1998.
16. Beck JD, Pankow J, Tyroler HA, Offenbacher S. Dental infections and atherosclerosis. Am Heart J 1999;138: S528-33.
17. Offenbacher S, Madianos PN, Champagne CM, et al. Periodontitis-atherosclerosis syndrome: an expanded model of pathogenesis. J Periodont Res 1999;34: 346-52.
18. Scannapieco FA, Genco RJ Association of periodontal infections with atherosclerotic and pulmonary diseases. J Periodont Res 1999;34:340-5.
19. Wu T,Trevisan M, Genco RJ, Dorn JP, Falkner KL, Sempos CT. Periodontal disease and risk of cerebrovascular disease: the first national health and nutrition examination survey and its follow-up study. Arch Intern Med 2000;160:2749-55.
20. Yano K, Rhoads GG, Kagan A, Tillotson J. Dietary intake and risk of coronary heart disease in Japanese men living in Hawaii. Am J Clin Nutr 1978;31:1270-9.
21. Kromhout D, Bosschieter E, de Lezenne Coulander C. Dietary fiber and 10-year mortality from coronary heart disease, cancer and all causes: the Zutphen study. Lancet 1982;ii:518-22.
22. Kushi LH, Lew RA, Stare FJ, et al. Diet and 20-year mortality from coronary heart disease: the Ireland-Boston diet-heart study. N Engl J Med 1985;312:811-18.
23. Joshipura KJ, Ascherio A, Manson JE. Fruit and vegetable intake in relation to risk of ischemic stroke. JAMA 1999;282: 1233-9.
24. Ripsin CM, Keenan JM, Jacobs DR Jr, et al. Oat products and lipid lowering: a meta-analysis. JAMA 1992;267:3317-25.
25. Risch HA, Jain M, Choi NW, et al. Dietary factors and the incidence of cancer of the stomach. Am J Epidemiol 1985;122:947-59.
26. Thun MJ,Calle EE, Namboodiri MM, et al. Risk factors for fatal colon cancer in a large prospective study. J Nat Canc Inst 1992;84:1491-500.
27. Cheng K, Day N. Nutrition and esophageal cancer. Canc Cause Contr 1996;7:33-40.
28. COMA. Nutritional Aspects of the Development of Cancer. London: Department of Health Committee on Medical Aspects of Food and Nutrition Policy, 1998:190-5.
29. Khaw KT, Woodhouse P. Interrelation of vitamin C, infection, haemostatic factors, and cardiovascular disease. Br Med J 1995;310:1559-63.
30. Ness AR, Powles JW, Khaw KT. Vitamin C and cardiovascular disease: a systematic review. J Cardiovascular Risk 1996; 3:513-21.
31. Ness AR, Khaw KT, Bingham S, Day NE. Vitamin C status and undiagnosed angina. J Cardiovascular Risk 1996;3:373-7.
32. Ness AR, Khaw KT, Bingham S, Day NE. Vitamin C status and respiratory func-

tion. Eur J Clin Nutr 1996;50:573-9.
33. Mares-Perlman JA, Lyle BJ, Klein R, et al. Vitamin supplement use and incident cataracts in a population-based study. Arch Ophthalmol 2000;118:1556-63.
34. Cumming RG, Mitchell P, Smith W. Diet and cataract: the Blue Mountains eye study. Ophthalmology 2000;107:450-6.
35. Taylor HR. Epidemiology of age-related cataract. Eye 1999;13:445-8.
36. Riemersma RA, Wood DA, MacIntyre CC, Elton RA, Gey KR, Oliver MF. Risk of angina pectoris and plasma concentrations of vitamins A, C and E and carotene. Lancet 1991;337:1-5.
37. Kohlmeier L, Kark JD, Gomez-Gracia E. Lycopene and myocardial infarction risk in the EURAMIC Study. Am J Epidemiol 1997;146:618-26.
38. Hirvonen T, Virtamo J, Korhonen P, Albanes D, Pietinen P. Intake of flavonoids, carotenoids, vitamins C and E, and risk of stroke in male smokers. Stroke 2000;31: 2301-6.
39. Arab L, Steck S. Lycopene and cardiovascular disease. Am J Clin Nutr 2000;71(6 Suppl):1691S-5S.
40. Omenn GS, Goodman GE, Thornquist MD, et al. Effects of a combination of beta-carotene and vitamin A on lung cancer and cardiovascular disease. N Engl J Med 1996;334:1150-5.
41. Rautalahti M, Albanes D, Virtamo J, Taylor PR, Huttunen JK, Heinonen OP. [Letter] Beta-carotene did not work: aftermath of the ATBC study. Cancer 1997; 114:235-6.
42. Omenn GS. Chemoprevention of lung cancer: the rise and demise of beta-carotene. Ann Rev Public Health 1998;19:73-99.
43. Wallace E. The effects of malnutrition in hospital. Br J Nurs 1993;2:66-71.
44. Tierney AJ. Undernutrition and elderly hospital patients: a review. J Adv Nurs 1996;23:228-36.
45. Incalzi RA, Gemma A, Capparella O, Cipriani L, Landi F, Carbonin P. Energy intake and in-hospital starvation. A clinically relevant relationship. Arch Intern Med 1996;156:425-9.
46. Wilson MM, Vaswani S, Liu D, Morley JE, Miller DK. Prevalence and causes of undernutrition in medical outpatients. Am J Med 1998;104:56-63.