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Abstract

Despite progress in dentistry, tooth loss in old age is still a reality, even more so in long-term-care residents. However, recent trends indicate that natural teeth are lost later in life. Functional decline and age-related pathologies have to be considered in oral health care for this vulnerable population. Retaining and restoring teeth and oral function in elders is important. Tooth loss significantly impairs masticatory performance, which cannot be fully restored by prosthodontic means. Hence an unconscious change in food intake occurs, often involving malnutrition and withdrawal from common meals. Poor oral appearance and bad breath may further impede social activities. Although a chewing activity may be beneficial for cognitive function, natural teeth can present a considerable risk for fragile elders, in whom aspiration of biofilm can lead to pneumonia and death. The presence of natural teeth is also correlated with higher life expectancy, but socio-economic confounding factors have to be considered. When evaluating oral health in the elderly population, standards and priorities for reporting oral health outcome [...]

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Oral health for an ageing population: the importance of a natural dentition in older adults

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Despite progress in dentistry, tooth loss in old age is still a reality, even more so in long-term-care residents. However, recent trends indicate that natural teeth are lost later in life. Functional decline and age-related pathologies have to be considered in oral health care for this vulnerable population. Retaining and restoring teeth and oral function in elders is important. Tooth loss significantly impairs masticatory performance, which cannot be fully restored by prosthodontic means. Hence an unconscious change in food intake occurs, often involving malnutrition and withdrawal from common meals. Poor oral appearance and bad breath may further impede social activities. Although a chewing activity may be beneficial for cognitive function, natural teeth can present a considerable risk for fragile elders, in whom aspiration of biofilm can lead to pneumonia and death. The presence of natural teeth is also correlated with higher life expectancy, but socio-economic confounding factors have to be considered. When evaluating oral health in the elderly population, standards and priorities for reporting oral health outcome measures have to be defined. Anatomical indicators such as the number of natural teeth or the presence of prostheses might be one option for reporting. However, functional indicators such as masticatory performance and patient-centred outcome measures may be more relevant. In conclusion, there is an overwhelming body of evidence that maintaining a healthy natural dentition in old age is beneficial from a structural, functional and psycho-social point of view.

Key words: Tooth loss, gerodontology, ageing, oral health, public health

INTRODUCTION

The permanent natural dentition is meant to last for life. However, physiological ageing and wear may modify dental appearance, morphology and function later in life.

In addition, dental decay and periodontal attachment loss may accumulate over a lifetime. Hence the natural dentition in the elderly looks and functions distinctly differently from the dentition of young adults.

This paper focuses on describing the changing patterns of tooth retention, the benefits of a natural dentition for masticatory performance, diet and food intake, quality of life, and cognitive functioning and longevity in elderly adults. It further highlights the importance of oral hygiene in fully or partially dentate elders with

respect to the adverse effects of chronic periodontal infection and aspiration pneumonia. It further elaborates on the use of standardised and relevant outcome measures in documenting oral health in the elderly population. In this context, standard indicators for scientific and public health research are proposed.

TOOTH LOSS – A DECLINING ENTITY?

Despite developments in prevention, restorative techniques and dental materials, tooth loss is still a reality in both, industrialised and developing countries^{1,2}. However, there are considerable differences between countries in the prevalence of edentulism and the incidence of tooth loss (*Figures 1 and 2*)³ Whereas prevalences of 0%–54.7% have been reported globally for the 65–74-year age group, this range was 2.7%–

WHO region / Country	Percentage edentulous	Age group (years)
African		
Madagascar	25	65-74
The Americas		
Canada	58	65+
USA	26	65-69
Eastern Mediterranean		
Egypt	7	65+
Lebanon	35	65-75
Saudi Arabia	31-64	65+
European		
Albania	69	65+
Austria	15	65-74
Bosnia and Herzegovina	78	65+
Bulgaria	53	65+
Denmark	27	65-74
Finland	41	65+
Hungary	27	65-74
Iceland	72	65-74
Italy	13	65-74
Lithuania	14	65-74
Poland	25	65-74
Romania	26	65-74
Slovakia	44	65-74
Slovenia	16	65+
United Kingdom	46	65+
South-East Asia		
India	19	65-74
Indonesia	24	65+
Sri Lanka	37	65-74
Thailand	16	65+
Western Pacific		
Cambodia	12	65-74
China	11	65-74
Malaysia	57	65+
Singapore	21	65+

Figure 1. Prevalence of edentulism in the WHO regions according to 'The global burden of oral disease and risks to oral health' data by Petersen *et al.* (2005).

27.6% in Europe and Israel⁴. Comparisons between countries are difficult, as economic circumstances, rural or urban living situations, attitudes towards dental care, and lifestyle factors may confound the reported prevalence⁵. There is still no consensus on whether risk factors related to dental disease or socio-behavioural factors are more relevant for tooth loss. Remarkably, the rate of edentulism was not associated with a country's economic situation or with the number of dentists per capita⁶.

In general, the rate of edentulism has decreased rapidly in the past few decades in many countries, and tooth loss occurs later in life^{4,7,8}. When

interpreting the falling rates of edentulism, it has to be borne in mind that more recent cohorts are demonstrating a different incidence of tooth loss, as shown by Slade and co-workers for the US population⁹.

As a consequence of these developments, we find more and more fully dentate or partially dentate persons in long-term care facilities (LTC). In old age – generally considered 85 years and above – the vast majority of the population in industrialised countries wears removable prostheses, with the majority being completely edentulous^{8,10}.

ORAL HEALTH IN OLD AGE

Physiological ageing is often complemented by multiple chronic diseases, polypharmacy, frailty, and finally the loss of autonomy and dependency for the activities of daily living (ADL). Impaired vision, lower tactile thresholds, and reduced dexterity render oral hygiene measures a challenge, and natural teeth are much more complex and time-consuming to clean than an edentulous mouth with a complete denture. Poor motor control and fragile oral tissues aggravate denture use, and reduced neuroplasticity hampers the adaptation to replacement prostheses. Age-related, mostly chronic pathologies, as well as physiological ageing, will also have to be considered in preventive oral healthcare in this vulnerable population.

Institutionalised elderly people, especially those with cognitive impairment, generally have more a compromised oral health, including fewer teeth, than their peers who live independently^{3,11}. When assistance is necessary for performing the ADL, oral hygiene is often neglected. Patients suffering from dementia are particularly affected^{12,13}. The result is a drastic increase in caries and infections, which leads to pain, tooth loss, and a reduction in quality of life^{14,15}.

In particular, fixed and removable implant restorations can present a challenge in dependent elders, both with regard to the handling of the prosthesis as well as to its cleaning by both patients and caregivers¹⁶. A special threat is posed by the accumulation of an oral biofilm on natural tooth surfaces, dental prostheses, or the tongue¹⁷. In the case of dysphagia, an illness frequently encountered in old age, oral bacteria are often carried into the bronchoalveolar system^{18,19}. This can lead to life-threatening aspiration pneumonia. A randomized-clinical trial demonstrated that the relative risk of developing aspiration pneumonia is statistically much lower when rigorous oral hygiene is practiced in nursing home residents²⁰. Sjøgren *et al.* suggested that 10% of nursing-home deaths from aspiration pneumonia could be avoided by improving oral hygiene²¹. Wearing dentures at night is likewise associated with oral infections, high microbial load,

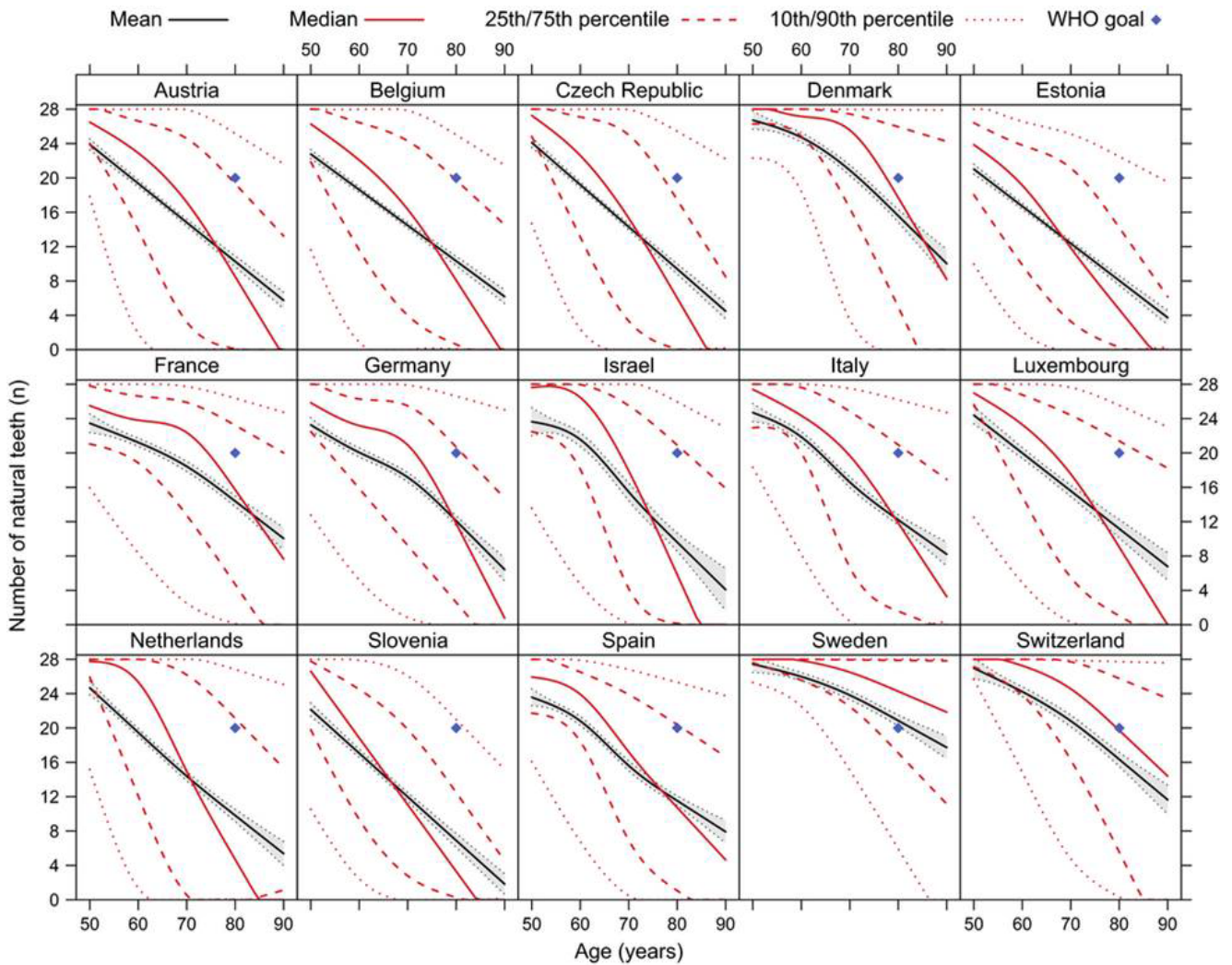


Figure 2. Epidemiological studies from the Survey of Health, Ageing and Retirement in Europe (SHARE) in Europe and Israel evince that tooth loss is occurring later in life. Number of natural teeth by country and age. The grey areas represent 95% confidence regions for the estimated outcome. Reprint permission from Stock *et al.* (2016).

and increased incidence of pneumonia²². Hence addressing neglected oral hygiene can become a major pre-occupation for elders dependent on care.

THE BENEFITS OF RETAINING NATURAL TEETH

Diet

Tooth loss leads to a deterioration in chewing efficiency^{23,24}, which often introduces an unnoticed change in diet, as the food choice is limited to what is feasible to chew with a reduced occlusal surface and/or removable prostheses²⁵. Often, the poor chewing capacity related to tooth loss is aggravated by ill-fitting dentures, infection, and pain, potentially leading to protein energy malnutrition, especially among older patients^{26,27}. Complete denture wearers tend to choose a diet that is low in protein, non-starch

polysaccharides, calcium and vitamins²⁶. Their inability to effectively comminute foodstuffs also has a negative effect on digestion^{28,29}. On the other hand, Weiss and coworkers reported that a Body Mass Index (BMI) of 28 or above is associated with reduced morbidity and mortality in very old subjects³⁰. Consequently, weight loss is a critical and closely monitored issue in geriatric care. Although a patient's chewing efficiency is not directly correlated to his or her weight, it may indirectly contribute towards a healthier nutritional intake, as it allows a wider selection of foodstuffs. Efficient chewing also means that meals do not have to be pureed, so that the dishes look more appetizing. Furthermore, institutionalised patients tend to withdraw from common meals when chewing difficulties preclude 'decent' table manners; however, company and social interaction seem to positively influence the caloric intake in geriatric patients³¹.

How many teeth are needed for maintaining satisfactory oral function? The shortened dental arch concept, as introduced by Kayser *et al.* in 1981, suggests that two occlusal units on either side would lead to a new equilibrium which provides acceptable oral function and remains stable over time³². For Japan, a '8020 Movement' was adopted, aiming for the presence of 20 or more natural teeth at the age of 80 years³³.

Improving chewing efficiency only through a dental restoration does not necessarily change the dietary intake, as other factors such as habits, food preferences, general health, mobility, culture, and cooking skills – as well as cognitive impairment and appetite – may play a role^{34,35}. While tailored nutritional counselling has been shown to increase the intake of fruits and vegetables in edentulous patients who were provided replacement dentures³⁶, it should be borne in mind that oral health and chewing efficiency are only one piece of the puzzle that influences the nutritional state of elderly individuals³⁷.

Quality of life

The term 'Quality of Life' has been used in medicine and psychology as a subjective indicator for more than 30 years³⁸. Health-Related QoL (HRQoL) can be understood as a multidimensional concept, which tries to explain the physical, psychological (emotional and mental), social and ADL aspects from an individual's point of view. Oral Health-Related Quality of Life (OHRQoL) describes the oral health-related well-being and satisfaction in these dimensions³⁹.

At all ages, a healthy natural dentition and a pleasing dental appearance contribute to Quality of Life. Bad breath and dental deterioration may foster social isolation, limit participation in social activities, and influence the judgements we make about another person's personality traits⁴⁰. Natural teeth allow for unrestricted psycho-social well-being, whereas tooth loss and replacement teeth are often associated with a loss of vitality and old age.

OHRQoL can be evaluated by several instruments⁴¹, with the Oral Health Impact Profile (OHIP) being one of the most popular⁴². The original version contains 49 items covering seven domains (functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability and handicap). A high OHIP score indicates a low OHRQoL. Steele depicted an almost incremental increase in OHIP scores in connection with tooth loss⁴³.

Apart from the psychological effects of tooth loss, impaired OHRQoL can largely be explained by the shortcomings of both conventional and implant-supported tooth replacement. A low number of natural teeth and deficiencies in masticatory

performance are significant predictors of low OHRQoL in the older population¹⁵. Any type of prosthesis can (more or less) replace the lost tissues and the facial appearance, but these generally fail to fully restore oral function. This is particularly true for removable prostheses, which may also cause discomfort and the sensation of a foreign body. Functional shortcomings comprise the chewing function, but also the tactile sensitivity of the teeth⁴⁴. Patients also report altered taste and temperature sensations, but these are mostly due to the presence of a palatal coverage. Bio-engineered replacement teeth provide hope that these shortcomings will be alleviated in the future, but the technique is still very far from use in clinical practice⁴⁵.

Cognition

It is well documented that patients with cognitive impairment have worse oral health than their cognitively intact peers. They not only have a lower number of natural teeth, but also present with a higher prevalence and incidence of caries and with more untreated lesions than their cognitively healthy peers^{46–50}. The presence of natural teeth in humans seems related to better cognitive functioning, with several plausible explanations for this correlation have been proposed⁵¹. Okamoto and collaborators⁴⁹ reviewed the literature on the interaction between occlusion and human brain function and concluded that 'mastication and other movements stimulate the activity in the cerebral cortex and may be helpful in preventing degradation of brain function'. The proposed reasoning is that blood flow in the brain is increased and parts of the cortex are activated during rhythmic chewing movements^{52,53}. Blood oxygen levels are reported to increase in the prefrontal cortex and the hippocampus, which may influence learning and memory performance⁵⁴. However, confounding socio-demographic factors include education and social status, which are closely related to tooth loss and cognitive function⁵⁵.

Another mechanism proposed as being a contributing factor for developing cognitive impairment is the presence of oral infections, such as periodontitis. Martande *et al.* reported a higher incidence and severity of periodontitis in patients with AD⁵⁶. Periodontal pathogens could provide inflammatory mediators due to daily, transient bacteremias, which in return increase the oxidative stress in Alzheimer's disease (AD)⁵⁷.

Animal models have tried to avoid these confounding factors and confirm that introducing poor mastication experimentally or administering a soft diet in mice may inhibit learning and memory performance^{53,58,59}. Whether the relationship between

mastication and cognition is observational or causal is still under discussion, and evidence of the effect of restorative dental measures is still scarce.

Reversing decline in cognitive function by improving chewing function through restorative means remains speculation, although preliminary clinical studies have suggested this reasoning^{60–62}. Mastication may be considered a mild and life-long daily physical exercise⁵². By influencing the heart rate and blood flow⁶³, chewing may have a preventive effect on the cognitive function similar to that of other physical sports⁶⁴. Gum-chewing therapy has even been proposed to increase attention in young adults⁶⁵.

Weijenberg *et al.*⁶⁶ were the first authors to state that ‘results of animal and human experimental studies suggest a causal relationship between mastication and cognition’. However, cognitive decline is a very complex process and may also be influenced by previous life events. Although the available evidence must be interpreted with caution, potential improvements in cognitive function would provide additional support for maintaining a natural dentition in old age.

Longevity

Cross-sectional epidemiological studies mostly indicate a greater number of teeth in the over 90-year age strata, which was a first indicator for higher mortality in the edentulous part of the population⁶⁷. More recently the correlation between life expectancy and the presence of natural teeth was confirmed in prospective, longitudinal studies. Holm-Pedersen *et al.* followed a cohort of 573 70-year-old Danish non-disabled elders over an observation period of 21 years and reported that ‘being edentulous or having 1–9 teeth was associated with onset of disability at age 75 and 80 years’ and that ‘persons being edentulous at age 70 were significantly higher at risk of mortality 21 years later (Hazard ratio 1.26, 95% CI 1.03–1.55)’⁶⁸. Other authors confirmed these findings with a shorter observation period and reported that this correlation was even more evident in men than in women⁶⁹. They concluded that ‘The number of teeth was a significant predictor of mortality independent of health factors, socio-economic status and lifestyle’. Again, socio-economic confounding factors have to be carefully considered when interpreting these findings, as edentulism is known as a condition of the poor and sick with a low level of education³.

STANDARD INDICATORS FOR EVALUATING ORAL HEALTH

When evaluating oral health in the elderly population, standards and priorities for reporting oral health outcome measures have to be defined. Anatomical

indicators such as the number of natural teeth or the presence of fixed or removable prostheses might be one option for reporting⁷⁰. Other structural indicators might comprise the loss of periodontal attachment, or in edentulous patients the degree of ridge resorption.

Functional indicators for oral health might be related to the masticatory performance. A recently developed bolus-kneading test, which measures colour mixing ability, provides an easy-to-apply and standardised evaluation method⁷¹. Another important functional indicator for oral health and disability may be the plaque and denture plaque indices, as they reflect the patient’s ability and motivation to maintain oral hygiene. These indices are of particular importance in estimating the health risks associated with oral biofilm and periodontal disease.

Oral health may equally be reported by the presence of disease or its long-term sequelae, frequently measured by the DMF index, Community periodontal index, Eichner index or the prevalence of a particular disease or dysfunction. Besides these ‘objective’ indicators of oral health and disability, the patient’s perception is key in evaluating the treatment needs of the ageing population. Reporting of patient-centred outcome measures is standard in today’s clinical studies. OHRQoL instruments such as OHIP⁴², GOHAI⁷² and others are needed for a valid estimation of the patient’s perspective. Last but not least, it seems important to evaluate the degree to which the patient’s oral condition may preclude his/her active participation in society.

A PLEA

Given the previously mentioned benefits of retaining the natural dentition until late in life, a plea for oral hygiene measures and minimally invasive restorations is indicated. Occlusal load from natural teeth stimulates the periodontal bone. Mechanoreceptors in the periodontal ligament enhance tactile sensitivity. But most importantly, natural dentition assures competent food comminution and fosters a healthy diet by allowing mastication of a large variety of foodstuffs. Good chewing performance is physical exercise for the chewing muscles and pumps oxygenated blood to the brain. ‘Active chewing’ enhances the clearance of the oral cavity, not only from food debris, but also from biofilm. Hence natural teeth foster the ‘self-cleaning’ of the mouth during a meal. And finally, natural teeth provide an age-adequate dental appearance, hence favouring social interaction and active participation in society.

CONCLUSION

There is an overwhelming body of evidence that maintaining a healthy natural dentition in old age is beneficial from a structural, functional and psycho-social

point of view. The goals of oral healthcare for the elderly population should therefore be to treat and prevent oral infection, foster Oral Health-Related Quality of Life, assure oral comfort, and provide the means to restore oral function where necessary and assure an acceptable dental appearance⁷³.

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Conflict of interest

The authors declare that they have no conflict of interest.

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