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Masticatory function and nutrition in old age

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Nutrition, quality of life, oro-facial function, dental state, dental prosthesis

Figure above: Elderly Patient with a combination of root caries and periodontal problems

SUMMARY

Nowadays, many people retain their natural teeth until late in life as a result of the large success of preventive strategies. However, there is still a very high prevalence of edentulism especially in elderly patients and many of these patients are provided with inadequate dental prostheses. In addition, many elderly citizens suffer from systemic diseases leading to increased drug prescription with age. This may have direct or indirect negative effects on the health and integrity of oral tissues like teeth, mucosa or muscles. There is growing evidence that a close interaction between the general medical condition and oral health exists. From a dental point of view, the chewing ability and capacity and its interaction with the nutritional status seem to be especially important. For example, complete denture wearers present a significant oral disability, which often leads to a gradual deterioration of their individual dietary habits. The improvement of maximum bite force and chewing efficiency may be an important prerequisite for an adequate nutrition. Those functional parameters can often be improved by providing functional dental prostheses or by stabilizing complete dentures with endosseous implants. Nevertheless, an improvement of the nutritional status can only be achieved through a close collaboration with dieticians or clinical nutritionists.

Introduction

The key factors for successful aging are described as intact social networks, physical and mental health, and physical and cognitive functionality (Rowe & Kahn 1997). The impact of diet or the nutritional status on all of these factors can be considerable. The aim of this review is to discuss the association between masticatory function and nutrition in older adults and the options and limits of dental treatment.

The intake of nutrients depends on different factors; dental status and oral health are only two aspects. Food choice is influenced not only by individual preference, taste, food texture, consistency, color, shape, size and temperature; also habits formed in childhood, family or regional culture, religious practice, economic status, mobility, and general health also play an important role (Chen & Engelen 2012). Most of these points also apply in old age; for example, eating habits formed in childhood and puberty are usually retained until late in life (Maynard et al. 2006).

With age, the number and severity of systemic diseases as well as the number of prescribed drugs often increase, while motor and cognitive abilities decline. Grocery shopping becomes difficult when there is insufficient physical strength to carry heavy bags or retirement payment is sparse and thus money is no longer available for meat, fresh fruit and vegetables. Preparing a balanced diet becomes difficult if vision deteriorates or there is little motivation to cook once the partner has died, for example. A Geneva study has shown that in a representative population sample of people over 80 years of age, 40% had fewer than three food items in stock in their refrigerator and 10% had absolutely none. This was also a significant predictor of hospitalization in the following month (Boumendjel et al. 2000).

According to Ettinger, the following factors can help to explain the development of malnutrition or undernutrition, particularly in older adults living alone (Ettinger 1998):

1. Low income and a lack of knowledge on how available funds can be used to obtain high-quality food.
2. Physical impairment resulting from acute or chronic diseases leading to exhaustion and weakness rendering shopping and food preparation difficult.
3. Kitchen facilities that are inadequate for meal preparation. This affects physically impaired people in particular.
4. Poor condition of dentures or prostheses leading to avoiding food items that are difficult to chew, with usually no adequate substitute in the dietary plan. Existing dietary patterns that provide inadequate nutrition as a consequence of lifelong unhealthy eating habits.
5. Depression, dementia, boredom, anxiety, loneliness or social isolation, which mean there is little stimulus to prepare a nutritious meal.
6. Multiple medications which suppress the appetite or have a laxative effect or lead to vomiting or nausea.

Malnutrition or undernutrition, or protein-energy malnutrition (PEM) as is terminologically more correct, refers to a loss of weight and body tissues. It can be classified into three broad categories, i.e. starvation, cachexia and sarcopenia, which often overlap, especially in elderly subjects (Jeejeebhoy 2012). Starvation results from a pure deficit of all macro- and micronutrients. Sarcopenia describes the loss of skeletal muscle mass and function occurring in older or immobilized subjects. Finally, cachexia is a complex metabolic syndrome associated with underlying disease, characterized by a weight loss of at least 5% in twelve months and three of the following criteria: low fat free mass, decreased muscle strength, fatigue, anorexia, and abnormal biological markers (CRP >5.0 mg/l, hemoglobin <120g/l, serum albumin <33 g/l) (Evans et al. 2008). According to this, patients who limit their food intake because of reduced masticatory function usually fall into the first two classes of protein-energy malnutrition. Exceptions include cancer patients who show signs of cachexia due to their underlying disease. Other consequences of PEM include low bone density, reduced cognitive functions, poor wound healing, and increased rates of hospitalization and mortality (Donini et al. 2013). Age-related weight loss, characterized by a loss of muscle mass and free body fat, has been demonstrated in longitudinal studies (Genton et al. 2011). The rapid loss of weight and muscle leads to reduced mobility and increases the likelihood of serious falls.

Despite the declining energy needs associated with increasing age, often an insufficient amount of food is consumed to avoid protein-energy malnutrition (Moynihan 2007). The reduced food intake along with a decline in the ability of the gastrointestinal tract to absorb nutrients also leads to a lack of micronutrients such as calcium and vitamin D, which counteract the development of osteoporosis. A deficiency of these substances can also lead to increased tooth loss and resorption of the alveolar bone (Kaye 2012, Nishida et al. 2000). However, a lack of other micronutrients such as iron, zinc, folic acid, and vitamins C and B12 was also described in association with oral and systemic symptoms such as burning mouth syndrome, atrophic mucosa, and a weakened immune status and coagulation system (Moynihan 2007). As malnutrition and undernutrition are often diagnosed quite late in general practice, the oral symptoms can provide a first clinical evidence.

Protein-energy malnutrition not only affects institutionalized older adults, but it is most common in this population group with a prevalence of 60–80% (Cereda et al. 2011). A large cross-sectional study revealed that the prevalence of being malnourished, undernourished or at risk of becoming so can be over 60% in adults over 65 years of age. The study also confirmed previous findings that the percentage is considerably higher among residents in care facilities or patients in geriatric hospitals (Kaiser et al. 2010, Mojon et al. 1999).

A Belgian study mentioned swallowing disorders, taste disorders, and transfer to an nursing home as examples of risk factors for developing undernutrition or malnutrition (Vanderwee et al. 2010). However, oral health and dental status in particular are often not considered in such studies. Evidently, poorly fitting dentures, denture pressure points, caries or periodontal diseases, as well as loose and missing teeth can have a considerable negative impact on food intake (Schimmel et al. 2008b) (Fig. 1).

Tooth loss in old age

Over recent decades, progress in preventive dentistry and an increasing awareness of "healthy teeth" have meant that older adults more often retain their teeth well into old age (Polzer et al. 2010). Although the average number of teeth lost per individual is decreasing, the prevalence of caries and periodontal diseases is increasing, particularly in older population groups (Micheelis & Schiffner 2006). This affects residents of nursing homes in particular (Peltola et al. 2004). Figures from Switzerland illustrate that 69.7% of the population is fitted with removable dentures in the 75- to 84-year-old age group. The percentage increases in those aged 85+ years to 85.9%, and almost

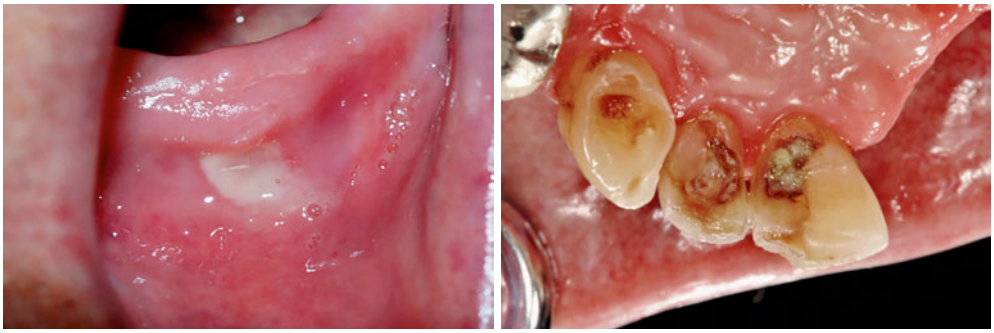

Fig. 1 Denture pressure points and caries can cause pain, leading to considerable reductions in masticatory function.

40% of people in this age group are edentulous, rehabilitated with complete dentures (Zitzmann et al. 2008). A cross-sectional study of patients hospitalized in a Swiss geriatric hospital found an even higher percentage of 52% of edentulous patients in the specific population (Katsoulis et al. 2012). Accordingly, many older adults have severely impaired oral functions. Although the situation could be improved for many patients by means of endosseous implants, many older people object to such a treatment (Müller et al. 2012b).

Masticatory ability and masticatory efficiency

When evaluating masticatory function, the terms masticatory ability and masticatory efficiency must be differentiated. The term masticatory ability refers to the subjective assessment of the masticatory function by the patient and is evaluated using interviews or special questionnaires. Masticatory efficiency is evaluated using objective tests and is defined as "the effort required to achieve a standardized degree of comminution" (The Academy of Prosthodontics 2005). For this purpose, a test food, usually nuts or silicone cubes, are chewed and then rinsed, collected, and dried. The degree of comminution d50 is analyzed using a sieve system or optoelectronic analysis and is used as a measure of masticatory efficiency (Manly & Braley 1950, Rosin & Rammler 1933). Other methods are based on the analysis of the color mixing of two-colored test foods (e.g. wax, chewing gum) (Halazonetis et al. 2013, Liedberg & Owall 1991, Prinz 1999, Schimmel et al. 2007, Speksnijder et al. 2009, van der Bilt et al. 2010). The results from these two-color mixing tests correlate significantly with the "sieving method" and they are particularly suitable for individuals with reduced masticatory function. They may also be applied in patients with swallowing disorders because no particles can be aspirated (Schimmel et al. 2011). For patients with severely reduced masticatory efficiency, a combination of objective and subjective evaluations of masticatory function is recommended. The objective methods are based on a previously defined number of masticatory cycles and are therefore not suitable to assess the individual chewing strategies of complete denture wearers, for example (Woda et al. 2011).

The color mixing tests are also suitable for use in private practice, hospitals or geriatric wards since they are cheap, simple and reliable. The patient is asked to chew a multicolored piece of chewing gum (e.g. Mentos Fruit Swing®) for 20 chewing cycles. The chewing gum is then removed from the mouth, placed in a plastic bag, and visually analyzed using a scale. The shape of the bolus and the degree of color mixture indicate the individual masticatory efficiency (Fig. 2).

If a patient is allocated to grade 1 or 2, it can be assumed that he or she has difficulties when eating foods with a normal consistency. For an even simpler test, the patient might simply bite on the examiner's finger to estimate the available masticatory force (Heath 1982). Chewing a piece of raw carrot can also provide initial information which food consistency could be recommended for the patient (Wöstmann et al. 2011).

Masticatory efficiency is related to the number and distribution of teeth as well as the type and quality of the prostheses.

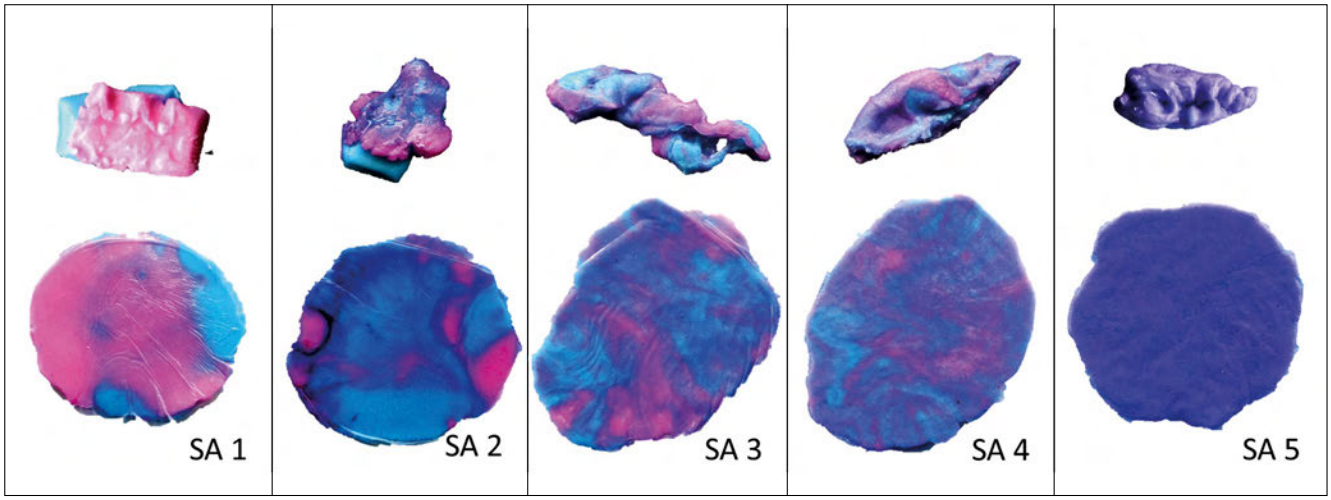

Fig. 2 Scale for rapidly determining masticatory efficiency using a multicolored piece of chewing gum. Grade SA 1: no color mixing, at most cusp impressions are visible; grade SA 2: no mixing of large parts of the chewing gum; grade SA 3: traces of the initial colors remain, slight bolus mixing; grade SA 4: good bolus mixing but no uniform color; grade SA 5: bolus perfectly mixed with a uniform color (Schimmel et al. 2007).

The jaw-closing force and the function of the cheeks, lips and tongue also have a considerable effect. While teeth and dentures serve to crush and grind down foodstuff, it is with the help of the intraoral and perioral muscles that the bolus is positioned between the dental arches and shaped. Saliva plays an important role in the formation of a cohesive bolus, which is then transported by the tongue to the esophagus (Schindler & Hugger 2006). The force and coordination of these structures can, for example, be reduced in stroke patients, which leads to a decrease in masticatory efficiency (Hirota et al. 2010, Schimmel et al. 2011). There is also rising evidence that masticatory function is impaired in those suffering from dementia (Elsig et al. 2013, Weijenberg et al. 2011).

The ability to crush and grind food is significantly dependent on the area of antagonistic occlusal surfaces (Bourdiol & Mioche 2000), and therefore declines with the loss of teeth (Manly & Braley 1950). Dentures can only in part compensate for this loss. Regardless of age, adults with a complete dentition have the highest masticatory efficiency, but the loss of even a few posterior teeth significantly reduces the chewing function (Fontijn-Tekamp et al. 2000). In one of our own studies we investigated the masticatory efficiency of edentulous subjects. We showed that those wearing conventional complete dentures had a significantly lower masticatory efficiency than those subjects with full dentition. Edentulous patients with mandibular implant-retained/-supported overdentures show a higher masticatory efficiency than complete denture wearers. These overdenture wearers had a comparable masticatory efficiency to edentulous patients with fixed implant bridges in both jaws. The masticatory efficiency of subjects with a full dentition was not met with any of those prosthetic treatment concepts. This may be linked to the loss of periodontal receptors and impaired jaw movements and reflexes (Müller et al. 2012a, Sessle 2006).

Older adults often suffer from age-related comorbidities, and with the increasing number of relevant systemic diseases, medications that may inhibit saliva flow are also being prescribed more often. This can lead to a wide range of oral problems. The retention of removable dentures is reduced, and the dentures often cause pain (Schimmel et al. 2008a). In addition, the food bolus cannot be formed and lubricated properly, which renders the act of swallowing difficult. The masticatory function is thus significantly affected by the quantity and consistency of saliva (Ikebe et al. 2006, Rhodus & Brown 1990).

The ability to crush and grind food is highly dependent on the available maximum jaw-closing force (van der Bilt 2011). Muscle mass declines over the course of the aging process; the jaw-closing muscles are no exception. Additionally, the age-related decline in the muscle cross-section of the masseter and pterygoid muscles is significantly increased in edentulism (Newton et al. 1987, Newton & Yemm 1986). Consequently, the maximum force that is available for comminution of food decreases over the course of a lifetime. For patients with mucosa-borne dentures, the maximum force is also ultimately limited by the pain threshold of the mucosa. Newton et al. have shown that overdentures that are supported by natural roots may counteract the waste of the jaw elevators (Newton et al. 2004). In patients in the fourth phase of life (adults of both a chronologically and biologically advanced age [Backes & Clemens 2003, Seifert]), it was shown that implant-supported overdentures may prevent or even reverse this atrophy (Müller et al. 2013, Schimmel et al. 2010). This emphasizes the preventive benefit of implant-borne prostheses in edentulous patients.

Dietary and physiological aspects

A causal correlation between tooth loss and nutritional status has only partly been documented in the literature, but it has repeatedly been shown that edentulous patients suffer more often from malnutrition or undernutrition when compared to those with a sufficient number of natural teeth (Ervin & Dye 2012, Moynihan et al. 2009, Savoca et al. 2010, Sheiham et al. 2002, Steele et al. 2004).

It appears that complete denture wearers alter and restrict their diet in the long term because of the prosthetic treatment, due to the development of significant functional impairments, particularly with advanced atrophy of the mandibular alveolar crest (van Kampen et al. 2004). This change in diet can, however, also occur rapidly and may represent a considerable burden for the patient as in the case of a total clearance of the natural dentition. Despite technically flawless preparation of immediate dentures, swelling and pain develops. After several weeks of healing, patients learn, depending on their individual cognitive and neuromuscular adaptability, to manipulate the mucosa-borne dentures and to function with them. It may take up to six months after delivering immediate complete dentures before the masticatory efficiency of those who have been wearing complete dentures for many years is reached (Bates & Stafford 1971, Müller et al. 1995). A study by Millwood & Heath illustrates this, often unnoticed, dietary change particularly well. There, most complete denture wearers only indicated meat as difficult to chew. Closer questioning revealed, however, that fruits with seeds, nuts, carrots, beef, toffee, or celery were no longer eaten because of problems with crushing and grinding food. Increased quantities of soft foods such as refined carbohydrates and fats were also introduced into the diet. Foodstuff is often overcooked until being soft, but important micronutrients are destroyed in the process (Millwood & Heath 2000).

In a British study, Sheiham et al. investigated the link between the number of natural teeth or edentulism and several nutritional parameters. They showed that the fewer natural teeth the study participants had retained (the most severely affected were complete denture wearers), the lower was the intake of vitamins, calcium, essential fatty acids, proteins, and calories (Sheiham et al. 2001). Missing calories were often compensated for with foods containing high amounts of sugar (Joshipura et al. 1996). People with their own posterior teeth also consumed more fruit and vegetables (Dhaliwal 2003). Having conventional complete dentures accordingly increases the risk of developing a protein-energy malnutrition (Cousson et al. 2012).

A very large US study reproduced these results. A sample of 4,442 study participants underwent dental examinations, and a 24-hour dietary profile was prepared. This study showed a significant link between dental status and the intake of calories and selected micronutrients, particularly for men. If the results were adjusted for the co-factors age, ethnic origin, education, and smoking status, it was apparent that these factors had a greater effect on the nutritional status than the dental status. This result highlights the complexity of individual dietary patterns (Ervin & Dye 2012).

Reduced masticatory efficiency in denture wearers also has a critical effect on oral-health-related quality of life (Stenman et al. 2012). Although foods that are difficult to chew can often be replaced by an equivalent (e.g. fruit by juices) (Moynihan et al. 2009) and reduced masticatory efficiency after tooth loss does not automatically result in poor blood parameters, the social components of shared meals and the choice of food are often diminished (Gil-Montoya et al. 2013, Kossioni & Bellou 2012).

Dentures

In private dental practice the situation might occur that a primary care physician suggests the provision of a dental prosthesis in order to treat the under- or malnutrition in older patients. The reasoning is often based on the assumption that an increased masticatory efficiency after prosthetic treatment will automatically improve the diet.

However, numerous well designed studies failed to demonstrate such an effect. McKenna et al. compared the effect of removable and fixed partial dentures on blood parameters such as serum albumin and did not detect any difference between the two groups, even though there were considerable differences in the size of the occlusal contact surface (McKenna et al. 2012). Previous studies correspondingly failed to demonstrate that partial dentures had an effect on dietary parameters (Gunne 1985, Liedberg et al. 2004, Moynihan et al. 2000).

Also, edentulous patients with mandibular implant-supported overdentures who therefore benefited from a significant increase in masticatory efficiency did not show any improvement in their nutritional status if their therapy was not accompanied by nutritional counselling (Sanchez-Ayala et al. 2010). On the other hand, a large Canadian randomized controlled clinical trial with adequate statistical power compared the diet of edentulous patients with conventional complete dentures and those with implant-supported overdentures. The results suggested that overdenture wearers consumed more fresh fruit and vegetables. However, a positive effect on other nutritional parameters, such as protein, energy, and vitamin intake, was not observed (Awad et al. 2012, Hamdan et al. 2013). Functionally adequate dentures are therefore an important prerequisite for improving the nutritional status of a patient, but treatment of malnutrition or undernutrition in old age should always be accompanied by nutritional counselling (Bradbury et al. 2006, Wöstmann et al. 2008). Even elderly denture patients who do not suffer from a protein-energy malnutrition may benefit from nutritional advice and may thus improve their diet (Budtz-Jorgensen et al. 2001).

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