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Original Article

Relationship between mastication and cognitive function in elderly in L'Aquila

Stefano Mummolo[1], Eleonora Ortu[1], Stefano Necozione[2], Annalisa Monaco[1], Giuseppe Marzo[1]

[1]Department of Life, Health and Environmental Sciences, Dental Clinic, University of L'Aquila, L'Aquila, Italy; [2]Department of Life, Health and Environmental Sciences, University of L'Aquila, L'Aquila, Italy

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Abstract: Patients with cognitive deficit have poor oral health and fewer teeth than cognitive normal elderly. The aim of the study was to investigate potential differences in masticatory function between elderly with dementia and those with normal cognitive function. Fifty-five patients (age >61; 82.05 ± 3.53) were enrolled in the study. Twenty-five subjects cognitively normal (10 females/15 males; 81.04 ± 4.89 years), were randomly selected and were assigned to Control Group. Thirty subjects (15 females/15 males; 83.16 ± 6.017 with cognitive impairments were randomly selected from hospitalized patients (Medically Assisted Residences RSA) and were assigned to Test Group. MMSE test, B-ADL and number of teeth were evaluated for each subject. The number of teeth in relation to levels of schooling is not resulted significative. In the cognitively impaired group 26 subjects had fewer than 20 teeth (86.6%); in the cognitively normal group 9 subjects had fewer than 20 teeth (36%). The correlation between number of teeth and age in both groups is significative ($p<0.05$). There is also a significative correlation between subjects with renal diseases and type II diabetes and number of teeth ($p<0.05$). Finally a significative correlation is present between number of teeth and sex of the patients ($p<0.05$) (**Table 1**). The results of the Wilcoxon's test revealed a significative correlation between MMSE in the two groups ($p<0.01$). There is also a significative correlation between the two groups and the educational background ($p<0.01$). The results of the study shows a clear correlation between tooth loss and cognitive function in elderly of L'Aquila.

Keywords: Dementia, tooth loss, cognitive impairment, MMSE

Introduction

Mastication has been shown to promote and preserve general health, especially (and it seems involved in maintenance of) the cognitive function of the brain, beyond its primary functions of food intake and digestion [1, 2]. Research on aging and mastication have shown that the decrease of number of teeth and the impairment jaw muscle activity due to aging cause a reduction in sensory input activity to the central nervous system [3, 4]. Functional magnetic resonance imaging and positron emission topography revealed that mastication increases cortical blood flow and widely activates various cortical areas of the somatosensory, supplementary motor, and insular cortices, as well as the striatum, thalamus and cerebellum [5, 6]. Evidences suggest a possible relationship between mastication and brain function [7, 8]. The World Health Organization (WHO 2006. Oral Health in Ageing Societies—integration of oral health and general health. WHO 2, 1-54) recognized the importance of oral health care and indicates a stringent need for research, training of caregivers, and development of policy regarding oral health care. Oral care should be actively provided to older persons in nursing homes and should furthermore not be limited to individuals retaining some teeth but extended to edentate persons as well [7]. Elderly people are at risk factors for cognitive impairment and for developing Alzheimer's disease (AD), which is one of the most common subtypes of dementia [9]. Among the risk factors including ageing, illiteracy, lower level of education, lower socioeconomic status [9], head trauma, genetic factors, cardiovascular risk factors, overweight, smoking, hypertension and diabetes mellitus, an inactive lifestyle, sur-

Table 1. Epidemiological and clinical characteristics of the two groups

	C.I. (Test Group)	C.N. (Control Group)
Age	83.16 (± 6.017)	81.04 (± 4.89)
Male	15	15
Female	15	10
Educational Background		
<8 years	21	2
>8 years	9	23
Number of teeth		
>20	4	16
<20	26	9
Diabete (Type II)		
Yes	5	5
No	25	20
Renal Diseases		
Yes	11	8
No	19	17
MMSE		
>20	5	24
<20	25	1
B-ADL		
Ind	1	11
Dip	29	14

prisingly, loss of teeth showed significant importance [10-13]. Mini-Mental State examination (MMSE) and the revised Hasegawa Dementia Rating Scale (HDS-R) has been used to evaluate higher brain function in standardized screening test. Recent data showed that masticatory ability and the number of natural teeth are related to cognitive function among the elderly without dementia [14, 15].

The purpose of the present study was to investigate potential differences in masticatory function between elderly with dementia and those with normal cognitive function. In particular, we matched age and basic activities of daily living (B-ADL), masticatory function assessed in terms of the presence/absence of teeth, educational background, health general conditions (Blood pressure, diabetes, and renal diseases) and cognitive function (MMSE).

Material and methods

This study was conducted in accordance with the Declaration of Helsinki. The Committee on Ethics in Science of the University of L'Aquila, L'Aquila, Italy approved the study and informed consent was obtained from each subject or from kins or legal representatives. The study was conducted between June 2011 and June 2012. Fifty-five patients (age >61; 82.05 ± 3.53) were enrolled in the study. Twenty-five subjects cognitively normal (10 females/15 males; 81.04 ± 4.89 years), were randomly selected from the patients attending the Dental Unit of the University Of L'Aquila and were assigned to Control Group. Thirty subjects (15 females/15 males; 83.16 ± 6.017 with cognitive impairments were randomly selected from hospitalized patients (Medically Assisted Residences RSA) and were assigned to Test Group. All subjects were living in L'Aquila, Italy at the time of the survey. Exclusion criteria were disorders interfering with psychometric assessment (severe blindness, terminal illness). Cognitive impairment was evaluated using the Mini-Mental State Examination (MMSE). The MMSE is the most commonly used instrument to gauge the severity of dementia by assessing cognitive functions. It comprises tests on orientation, registration, short-term memory, language use, comprehension, and basic motor skills (**Figure 1**). The score ranges from 0-30. Patients are considered to be in a mild stage of the disease when scoring 20 points or above; in a moderate stage when scoring between 10 and 19; and in a severe stage when scoring 9 or less [16]. In this study we considered scores of 20 and less represent low cognitive ability, and scores of 21 and greater representing normal cognitive function (MMSE >20 or MMSE <20). B-ADL (BASIC ACTIVITIES OF DAILY LIVING) was rated on five items: walking, eating, excreting, bathing and dressing. For each of these activities there some questions to be answered (**Figure 2**). Later respondents were classified as either 'dependent' or 'independent' by themselves or their caregivers. Respondents who rated themselves as completely independent on all five items were defined as 'independent', whereas respondents who rated themselves as dependent on one or more of the five B-ADL items were 'dependent' [17]. Also, for each patients was evaluated the presence of chronic medical diseases such as hypertension, cardiac diseas-

Mini-Mental State Examination (MMSE)

Patient's Name: _____ Date: _____

Instructions: Score one point for each correct response within each question or activity.

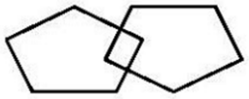
Maximum Score	Patient's Score	Questions
5		"What is the year? Season? Date? Day? Month?"
5		"Where are we now? State? County? Town/city? Hospital? Floor?"
3		The examiner names three unrelated objects clearly and slowly, then the instructor asks the patient to name all three of them. The patient's response is used for scoring. The examiner repeats them until patient learns all of them, if possible.
5		"I would like you to count backward from 100 by sevens." (93, 86, 79, 72, 65, …) Alternative: "Spell WORLD backwards." (D-L-R-O-W)
3		"Earlier I told you the names of three things. Can you tell me what those were?"
2		Show the patient two simple objects, such as a wristwatch and a pencil, and ask the patient to name them.
1		"Repeat the phrase: 'No ifs, ands, or buts.'"
3		"Take the paper in your right hand, fold it in half, and put it on the floor." (The examiner gives the patient a piece of blank paper.)
1		"Please read this and do what it says." (Written instruction is "Close your eyes.")
1		"Make up and write a sentence about anything." (This sentence must contain a noun and a verb.)
1		"Please copy this picture." (The examiner gives the patient a blank piece of paper and asks him/her to draw the symbol below. All 10 angles must be present and two must intersect.) 
30		TOTAL

Figure 1. MMSE test.

es, diabetes, renal diseases, respiratory tract diseases, cerebrovascular diseases, rheumatoid arthritis and hepatic diseases as suggested by the recent literature [18, 19].

A dental examination was carried out by two dentists calibrated as to the techniques, with the dentist and the subject in a sitting position under artificial lighting. The number of teeth was recorded for each subject (<20 or >20) [19]. The remaining teeth were defined as healthy, carious or treated teeth (including crowned, inlay, and abutment teeth for bridge work), inclusive of completely erupted third

KATZ BASIC ACTIVITIES OF DAILY LIVING (ADL) SCALE		
	Independent	
	YES	NO
1 Bathing (sponge bath, tub bath or shower) Receive either no assistance or assistance in bathing only one part of body		
2 Dressing – Gets clothes and dresses without any assistance except for tying shoes		
3 Toileting - Goes to toilet room, uses toilet, arranges clothes, and returns without any assistance (may use cane or walker for support and may use bedpan/urinal at night)		
4 Transferring – Moves in and out of bed and chair without assistance (may use can or walker)		
5 Continence – Control bowel and bladder completely by self (without occasional "accidents")		
6 Feeding – Feeds self without assistance (except for help with cutting meat or buttering bread)		

LAWTON BRODY INSTRUMENTAL ACTIVITIES OF DAILY LIVING SCALE (I.A.D.L.)			
A. Ability to use telephone		E. Laundry	
1. Operates telephone on own initiative- locks up and dials number, etc	1	1. Does personal laundry completely	1
2. Dials a few well know number	1	2. Launders small items- rinses stockings, etc.	1
3. Answer the telephone but does not dial	1	3. All laundry must be done by others	0
4. Does not use telephone at all	0		
B. Shopping		F. Mode of Transportation	
1. Takes care of all shopping needs independently	1	1. Travels independently on public transportation or drive own car	1
2. Shops independently for small purchases	0	2. Arranges own travel via taxi, but does not otherwise use public transportation	1
3. Needs to be accompanied on any shopping trip	0	3. Travels on public transportation when accompanied by another	1
4. Completely unable to shop	0	4. Travel limited to taxi or car with assistance of another	0
		5. Does not travel at all	0
C. Food Preparation		G. Responsibility for own medications	
1. Plans, prepares and serves independently	1	1. Is responsible for taking medications in correct dosage at correct time	1
2. Prepares adequate meals if supplied with ingredients	0	2. Takes responsibility if medications is prepared in advance in separate dosage	0
3. Heats, serves and prepares meals, or prepares meals, or prepares meals but does not maintain adequate diet	0	3. Is not capable of dispending own medications	0
4. Needs to have meals prepared and served	0		
D. Housekeeping		H. Ability to Handle Finances	
1.Maintains house alone or with occasional assistance (e.g. "heavy work domestic help")	1	1.Manage financial matters independently (budgets, writes checks, pays rent, bills, goes to bank), collects and keeps track of income	1
2. Performs light daily tasks such as dish washing, bed making	1	2. Manage day to day purchases, but needs help with banking, major purchases, etch	1
3. Performs light daily tasks but cannot maintain acceptable level of cleanliness	1	3. Incapable of handing money	0
4. Needs help with all home maintenance tasks	1		
5. Does not participate in any housekeeping tasks	0		

Figure 2. B-ADL test.

molars. In the study were not considered teeth with chronic periodontitis; also were not considered partial oftotal removable prosthesis [19].

Statistical analysis

The Student's t-test was used as test of significance and correlation coefficient were performed with respect to age, gender, systemic diseases, educational background, MMSE, B-ADL and number of teeth. The level of significance was assumed to be $p \leq 0.05$ for all tests. Test group were compared to the control group using Wilcoxon rank sum tests. The level of significance was assumed to be $p \leq 0.01$.

Results

Table 1 summarizes the epidemiological and clinical characteristics of control and test

groups. The mean age of subjects in the cognitively normal group was 81.04 years (s.d. 4.89 years), and in the cognitively impaired group 83.16 years (s.d. 6.017 years). There was no significant difference in age between the groups. The number of teeth in relation to levels of schooling is not resulted significative. In the cognitively impaired group 26 subjects had fewer than 20 teeth (86.6%); in the cognitively normal group 9 subjects had fewer than 20 teeth (36%). The correlation between number of teeth and age in both groups is significative ($p<0.05$). There is also a significative correlation between subjects with renal diseases and type II diabetes and number of teeth ($p<0.05$). Finally a significative correlation is present between number of teeth and sex of the patients ($p<0.05$). The results of the Wilcoxon's test revealed a significative correlation between MMSE in the two groups ($p<0.01$). There is also a significative correlation between the two groups and the educational background ($p< 0.01$).

Discussion

Dysfunctional mastication affects cognitive function, and reduced mastication contributes to senile dementia, Alzheimer's disease, and a declining quality of life in the elderly. In particular, the systemic effects of tooth loss are an epidemiologic risk factor for Alzheimer's disease. In fact, missing teeth, due to dental caries and periodontal diseases are common in the elderly, and reduce their ability to masticate [20]. Particularly, the loss of teeth induces pathologic changes in the hippocampus and deficits in learning and memory. In our work we looked for a relationship between edentulism and dementia in elderly patients in L'Aquila. Following occlusion and age-matching, masticatory function was compared between cognitively impaired and cognitively normal elderly. The results indicated a close association between masticatory function and age in both groups. In the cognitively impaired group 26 subjects had fewer than 20 teeth (86.6%); in the cognitively normal group 9 subjects had fewer than 20 teeth (36%). Both age and tooth loss are associated with each other. Age and tooth loss are expected to have a complex relationship with oral health-related quality of life [21]. Multiple tooth loss and difficulty chewing food were found to correlate with significantly greater odds of cognitive impairment. The difference remained significant even after history of depression and mental illness were added to the analysis [22]. Also, persons with cognitive impairment may have poorer ability to maintain oral hygiene, which would increase the risk of dental caries and periodontal disease, the major causes of tooth loss and limited ability to chew hard food [23, 24]. The results indicated also that the ability to chew is not be associated with the basic activities of daily living (B-ADL). Later we analyzed occlusion and pathologies (renal diseases and type II diabetes) in both groups. The results showed a relationship between number of teeth (<20) and subjects with these diseases ($p<0.05$). Theadults with diabetes are at higher risk of experiencing tooth loss and edentulism than are adults without diabetes. However, although the association between diabetes and periodontal disease is well established, health care professionals also need to recognize the risk of tooth loss and its effect on quality of life among people with diabetes [25, 26]. Also periodontal infection and tooth loss contribute to chronic kidney disease [27]. Finally we compared number of teeth and gender ($p<0.05$). 15 males have less of 20 teeth, and 19 female have less of 20 teeth. This outcome seems to be the same from others outcomes. Infact, the prevalence of edentulism among the elderly Italian population studied was at the high end among Western countries, and higher in women than in men [28]. In women, tooth loss is correlated with aging, female events (pregnancies, menopausal status), and living alone. In men, aging and smoking are important determinants of edentulism, which is associated with the risk condition of hypoalbuminemia.

Difficulty in chewing was associated with dentition type [28, 29]. The educational background is not correlated with the number of teeth but is correlated with the groups. For this reason, theanalysis shows that the patients with an elevated educational background have also greater cognitive ability. A recent review and meta-analysis demonstrates robust evidence that a high level education in early life is related with a significant reduction both in the prevalence and incidence of dementia, including Alzheimer's disease and vascular dementia. These results are in accordance with the Cognitive Reserve hypothesis, which assumes some aspects of life experience such as education protects against the onset of dementia. Education also

influences the course and outcome of the disease in terms the pattern of cognitive decline and underlying brain pathology. As a prevention strategy Ritchie suggests that increasing a population's ability to use skills, knowledge, and experience (crystallized intelligence) as well as increasing vegetable consumption, and eliminating depression and diabetes would have a greater impact on the prevalence and incidence of dementia than modifying known genetic risk factors [30-32]. Subjects with dementia or cognitive impairments, by our data, obviously have an MMSE lower as suggested by literature [33, 34]. The results of the study show a clear correlation between tooth loss and cognitive function. The clinical relevance of these results is evident. In the general population, and in those nursing facilities caring for persons with dementia in particular, attention and priority should be given to prevention of loss of masticatory function and treatment of oral impairments to stabilize or even improve cognition.

Disclosure of conflict of interest

None.

Address correspondence to: Eleonora Ortu, Department of Life, Health and Environmental Sciences, Dental Clinic, University of L'Aquila, Via Vetoio 67100, L'Aquila, Italy. Tel: +39 0862 434973; E-mail: eleortu@gmail.com

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