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Tooth loss and cognitive functions among older adults

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Abstract

Objective. To evaluate the association between the number of teeth and cognitive functions adjusted for age and education level in a cohort of older adults living in Sweden. ***Materials and methods.*** The study employed a cross-sectional design in which 1147 individuals between 60–96 years underwent a clinical oral examination. The cognitive functions were assessed using Mini-Mental State Examination (MMSE) and Clock-test. The level of education was obtained from a questionnaire. Data were subjected to Chi-square tests and multivariate logistic regression analyses were employed, grouping the different variables into pre-determined categories. ***Results.*** The co-variables age and education were significantly associated with the number of teeth ($p < 0.05$). The multivariate logistic regression analysis revealed that the association between the number of teeth and the cognitive functions persisted even after adjusting for age and level of education. ***Conclusions.*** The findings suggest that the presence of teeth may be of importance for cognitive abilities in older adults.

Key Words: *cognitive impairment, dementia, elderly, oral health*

Introduction

The relationship between oral health and medical conditions such as diabetes mellitus, cardiovascular diseases and rheumatoid arthritis has been comprehensively studied and new knowledge has been attained regarding possible co-variation and causality [1–3]. The median age of the world's population is increasing; the proportion aged ≥65 is projected to increase by ~ 550 million to 973 million in the coming decades [4]. With an increased age, cognitive impairment and dementia is becoming more prevalent [5]. Alzheimer's disease is the most common form of dementia and is reported to be frequent (24–33%) among individuals in the western world in the ages above 85 years [5]. Modifiable risk factors such as physical activity, cognitive stimulation and smoking have been identified [6,7]. High blood pressure and obesity are medical conditions also associated with an increased risk for dementia [6,8]. The initial symptoms of Alzheimer's disease are decline in different cognitive domains often associated with episodic memory. Cognitive tests have been shown to be effective in predicting risk for Alzheimer's disease [9].

Previous retrospective and population-based studies have suggested an association between dental health, tooth loss and cognitive function [10–12]. Early tooth loss has been reported to be associated with the development of Alzheimer's disease [13]. Furthermore, experimental animal studies have revealed an influence on memory capacity after loss of molars [14,15]. There is, however, a lack of information regarding the influence of different explanatory covariates such as age and education. Previous research has often been based on self-reported oral status and various simplified cognitive tests that may have affected the outcome. The aim of this study was, therefore, to assess the relationship between cognitive functions, assessed by Mini-Mental State Examination (MMSE) and Clock-test and the number of teeth in a cohort of older adults in Sweden when adjusted for age and level of education.

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Materials and methods

Subjects

All subjects in this cross-sectional study were participants in the Swedish National Study on Ageing and Care (SNAC), which is a population-based, multicentre cohort study. The study has four participating centres in Sweden and one of the centres is Blekinge (SNAC-Blekinge), which involves the Karlskrona community, with 60 600 inhabitants. A more detailed description of the study design and structure is outlined by Lagergren et al. [16]. The individuals were randomly selected from the Swedish civil registration database in the age cohorts of 60, 66, 72 and 78 years. In the age cohorts of 81, 84, 87, 90, 93 and 96 years, all individuals were invited. Ten per cent of the entire population aged 60 years and older in the community participated in the study. The individuals were enrolled between 2001–2004 and, in total, 2312 were invited and 1402 accepted. The response rate was 62%. Reasons for not participating were feeling too sick to be able to participate (n = 91), non-responding (n = 64) and unwillingness to participate (n = 755). Individuals at ages 60 and 66 were allocated to the young old age cohort, those aged 72 and 78 to the old age cohort and individuals >81 years of age were allocated to the old-old age cohort. The participants were invited by mail to take part in a medical, psychological and dental examination by the members of the research team. The examination could also be performed in their homes if they were unable to come to the research centre. All subjects gave their signed informed consent. Subjects also signed an approved release form for their medical records. The Research Ethics Committee at Lund University approved the study (LU 605-00, LU 744-00).

Cognitive tests

Mini-Mental State Examination (MMSE). This test is one of the most widely used tests to screen for cognitive status and cognitive impairment. The test consists of 20 items, resulting in a total score of 30 [17]. The test result may reflect cognitive abilities such as orientation, memory, attention and concentration, language and praxis [18,19]. Test results lower than 29 are considered to reflect pathological changes and in this study a score <25 was used as a cut-off value [20].

Clock-test. This is a brief cognitive test widely used in assessment of dementia [21]. The participants were asked to draw an analogue clock face in a pre-drawn circle with the numbers in correct position and then the arms indicating the time 'ten minutes past eleven' [22]. The results are scored from 0–10 and reflect verbal comprehension, executive function and visuoconstructional skills [23]. Correlation between impaired results on clock-test and pathology in parietal lobes has been identified in Alzheimer's disease [24]. In this study, a score <8 was used as the cut-off value for lower cognitive function [22].

Education. The level of education was captured from a comprehensive questionnaire and categorized according to final school grade, ≤9 years or more.

Oral examination

An oral examination including clinical registration of the number of teeth present was performed by a specially trained dental hygienist. Panoramic radiographs were taken using an orthopantomograph (Instrumentarium Dental, OP 100; Tuuaula, Finland; standard exposure 75 kV/10 mA). Presence or absence of teeth was also assessed from the radiographs. If a disagreement in the number of teeth present occurred, due to, for example, pontics in fixed dental prosthesis, implants and root-remnants, the radiographs were re-assessed and the number of teeth counted on the radiograph were used in the analysis. Erupted third molars were included in the analysis. The study individuals were allocated into three groups according to number of teeth: edentulous, 1–19 teeth and ≥20 teeth.

Statistical methods

A statistical software program (IBM SPSS version 21.0, IBM Statistics, Amorak, NY) was used for the analysis. Descriptive statistics were used to present the population. Associations between tooth loss, on the one hand, and age cohort, sex and educational level, on the other hand, were tested using the Chi-2 test. Associations between the candidate explanatory variables (i.e. tooth loss, age cohort, sex and educational level) and the cognitive function variables were analysed using logistic regression. The association between tooth loss and the cognitive function variables were analysed first by univariate logistic regression and thereafter with adjustment for the influential explanatory co-variables by multivariate logistic regression. Odds ratios (OR), 95% confidence interval (CI) and p-values were calculated; p-values < 0.05 were regarded as statistically significant.

Results

A total of 1402 individuals (58.2% women) were included in the study. Data on dental status was lacking in 255 individuals and, thus, the final results were based on 1147 subjects. The relationship between the number of teeth and age, gender and level of education is shown in Table I. The

Table I. Chi-2 analysis of the explanatory covariables age, education and gender and number of teeth.

	0 teeth, *n* (%)	1–19 teeth, *n* (%)	≥20, *n* (%)	Total, *n* (%)	χ^2 tests
Young old, 60, 66 years	18 (4.9%)	85 (23.1%)	265 (72.0%)	368 (100.0 %)	0.000
Old, 72, 78 years	46 (14.9%)	128 (41.4%)	135 (43.7%)	309 (100.0 %)	0.000
Old old, ≥81 years	136 (28.9%)	242 (51.5 %)	92 (19.6%)	470 (100.0 %)	0.000
Total	200 (17.4%)	455 (39.7%)	492 (42.9%)	1147 (100.0 %)	
Education					
≤9 years	179 (95.7%)	399 (92.6%)	351 (73.0%)	929 (84.5%)	0.000
>9 years	8 (4.3%)	32 (7.4%)	130 (27.0%)	170 (15.5%)	0.000
Total	187 (100%)	431 (100%)	481 (100%)	1099 (100%)	
Gender					
Female	126 (62.6%)	243 (53.4%)	269 (54.7%)	638 (55.5%)	NS
Male	74 (37.4%)	212 (46.6%)	223 (45.3%)	509 (44.5%)	NS
Total	200 (100%)	455 (100%)	492 (100%)	1147 (100%)	

explanatory co-variables age and education were significantly associated to number of teeth ($p < 0.05$). Results from logistic regression regarding the number of teeth and the MMSE and Clock-test, unadjusted for age and education, are presented in Tables II and III. The risk for low cognitive scores was statistically related to the number of teeth. The odds ratio for having MMSE <25 was 3.2 in the dentate group (1–19 teeth) and 9.2 in the edentulous group. The corresponding values for the Clock-test <8 were 2.9 and 4.3, respectively.

Results from the multivariate logistic regression analysis when age and education were entered into the model are also presented in Tables II and III. The results demonstrated that the influence of the number of teeth on cognitive functions persisted for the edentulous groups when the results were adjusted for age and education. A statistically significant difference between the dentate groups having more or less than 20 teeth remained concerning the Clock-test <8 ($p = 0.03$). No gender differences could be identified.

Discussion

This cross-sectional study examined the association between tooth loss and cognitive function in a sample of individuals aged 60 years and older. It is generally considered that results obtained using MMSE and the

Table II. Multivariate logistic regression for the outcome MMSE <25 and the explanatory variables number of teeth, age and education.

	Without adjustments			With adjustments		
Explanatory variable category	OR (95% CI)*	*n*	*p*-value	OR (95% CI)*	*n*	*p*-value
Number of teeth						
0	9.2 (5.9–14.3)	196	0.000	3.2 (1.9–53)	183	< 0.001
1–19	3.2 (2.1–4.8)	451	0.000	1.3 (0.84–22)	427	0.22
≥20	1.0 (reference)	491		1.0 (reference)	480	
Age						
Young old; 60, 66 years				1.0 (reference)	363	
Old; 72, 78 years				2.7 (1.3–5.4)	299	0.005
Old old; ≥81 years				8.5 (4.4–16.2)	428	< 0.001
Education						
≤9 years				2.7 (1.3–5.9)	921	0.01
>9 years				1.0 (reference)	169	

*Odds ratio with 95% confidence interval.

Table III. Multivariate logistic regression analysis for the outcome Clock-test <8 and the explanatory variables number of teeth, age and education.

	Without adjustments			With adjustments		
Explanatory variable category	OR (95% CI)*	*n*	*p*-value	OR (95% CI)*	*n*	*p*-value
Number of teeth						
0	4.3 (2.9–6.5)	168	0.000	1.9 (1.2–3.0)	160	0.007
1–19	2.9 (2.1–4.1)	431	0.000	1.5 (1.1–2.3)	410	0.03
≥20	1.0 (reference)	482		1.0 (reference)	471	
Age						
Young old; 60, 66 years				1.0 (reference)	362	
Old; 72,78 years				2.1 (1.3–3.4)	292	0.002
Old old; ≥81 years				5.0 (3.2–7.8)	387	< 0.001
Education						
≤9 years				1.6 (0.9–2.7)	877	0.09
>9 years				1.0 (reference)	164	

*Odds ratio with 95% confidence interval.

Clock-test are strongly affected by age and the level of education. In this study the tests are used as screening tools for cognitive functions and, thus, an arbitrary cut-off level <25 was adopted. Age and level of education were used as covariates. Our main and novel finding was that the number of teeth was of importance for the outcome of the cognitive tests, even when adjusted for the age and education. The edentulous group showed greater odds of having the lower cut-off value on both MMSE and Clock-test. Regarding the Clock-test, a difference between the dentate groups (1–19 teeth and more than 20 teeth) could be identified. Our findings are mainly in accordance with previous studies [25,26]. Sparks-Stein et al. [26] reported that few retained teeth were significantly associated with prevalence of dementia in a group of Roman Catholic sisters. In a longitudinal follow-up study on men in the Boston area, tooth loss and periodontal disease progression independently increased the risks of low cognitive test scores at follow-up [27]. In contrast to the present study, Lexonboom et al. [12] reported that the association between tooth loss and cognitive impairment was due to gender, age and education as the odds ratio became non-significant when these variables were entered into the model [12].

One of the strengths with the present paper was that the oral data were not self-reported. The teeth were registered both clinically and with radiographs in contrast to several earlier reports based on self-reported data [10,12] or analyses of dental charts [26]. The grouping according to the number of teeth was based on the discussion that 20 teeth are needed for persistent oral health and function [28]. However, we have not further analysed the teeth's positions in the arch and its influence on the occlusion except for the prevalence of molar teeth. We could not identify any difference between molar and non-molar teeth. There were not enough individuals with implant-supported prosthesis to make a sub-analysis.

In the present paper two cognitive tests were used. This may provide a broader perspective of the individual's cognitive function. The tests were carried out and analysed by clinicians specially trained for the purpose in order to improve the reliability of the results. One reason for the discrepancies of results between the present paper and others [12,25,29] may be related to the sample selection and the exclusion criteria applied. Lexomboon et al. [12] excluded individuals with dementia, stroke and individuals with hearing problems. Bergdahl et al. [25] and Grabe et al. [29] excluded individuals with diseases such as mental illness, cardiovascular diseases and cerebral thrombosis. In the present report, all individuals that were able to visit the research centre and were capable to perform the cognitive tests were included. Therefore, we consider our findings to be of good external validity. It should be underlined that the drop-out group lacking dental examination (n = 255) were older then the study group; 75% belonged to the old-old cohort and performed inferior results on the cognitive tests.

One possible limitation of the present paper was that age and education were given the same impact as co-variables in the different age cohorts. The Swedish education system changed significantly in the middle of the 20th century, resulting in increased access to higher education for individuals in the young-old cohort compared to the individuals in the two other age cohorts. Additionally, the individuals in the young old cohort may have been exposed to more preventive-oriented dental services. In the older cohorts teeth may have been extracted due to lack of dental services and lack of a dental insurance system.

Another limitation with the present cross-sectional study design is that it is not possible to know if loss of teeth or cognitive impairment occurs first. To answer such a question longitudinal studies are needed.

Different explanatory theories regarding the interactions between dental status and cognitive function have been discussed. Whether it is the chewing ability, number of teeth or the burden of oral inflammatory diseases through life is still an open question. Periodontitis may contribute to the pathological process in cognitive impairment and dementia [30]. This needs to be further elucidated in longitudinal studies.

Conclusions

Within the limitation of the present study, a statistically significant association of the number of teeth on cognitive abilities of older adults were demonstrated when adjusted for age and level of education. The findings reinforce the assumption that the presence of teeth may be of importance for cognitive abilities in older adults.

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