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ORIGINAL ARTICLE

The relation between teeth loss and cognitive decline among Saudi population in the city of Riyadh: A pilot study

Randa ALFotawi [a,*], Sarah Alzahrani [b], Reem Alhefdhi [b], Asma Altamimi [b], Alia Alfadhel [c], Ahmed Alshareef [b], Bader Aldawsari [b], Saleh Sonbol [b], Faisal Alsubaie [b], Abdulrahman Alwahibi [d], Aljoharah AL-Sinaidi [e]

[a] *Oral and Maxillofacial Department, Dental Faculty, King Saud University, Saudi Arabia*
[b] *Dental Intern, Collage of Dentistry, King Saud University, Riyadh, Saudia Arabia*
[c] *Dept. of Dentistry, Saudi, Ministry of Health, AlBaha Region, Saudi Arabia*
[d] *Psychiatry Dept. King Saud University Medical city, collage of Medicine, King Saud University, Riyadh, Saudia Arabia*
[e] *Department of Periodontics and Community Dentistry, Dept of Periodontology Dental Faculty, King Saud University Riyadh, Saudi Arabia*

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KEYWORDS

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Abstract *Background:* Teeth are necessary for sensory input to the brain during the chewing process, but how the decrease in this sensory input, due to loss of teeth, may cause weak memory and lead to cognitive decline is not well understood. This pilot public survey aiming to assess the correlation between the number of missing teeth, periodontal disease, and cognitive skill in the city of Riyadh.

Material& Methods: A multicenter cross-sectional survey, targeting geriatric population aged ≥60 years, was performed in Riyadh City, Saudi Arabia. The Montreal Cognitive Assessment (MoCA) was conducted to all participants to assess their cognitive function. Assessment of oral health status was carried out, including the number of present dentation and their periodontal status. Community periodontal-index (CPI) was used to assess the periodontal condition. The primary variables were number of missing teeth, periodontal disease and MoCA test scores. Chi-square test and Pearson's correlation coefficients were computed and the significant *P*- value was set at <0.05.

Results: Of 95 participants, overall, 57 (60%) and 38 (40%) were male and female, respectively, with a mean age of 65.67 ± 6.32 years. Females showed more significant cognitive decline than

* Corresponding author.
E-mail address: ralfotawei@ksu.edu.sa (R. ALFotawi).
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males ($P < 0.001$). Cognitive decline was significantly high in participants with low educational level 19 (95%), unemployment 41 (79%), and lower income people 26 (79%), while being cognitive intact was significantly higher in highly educated 13 (87%), retired 21 (62%), and higher income people 28 (74%) at ($P < 0.001$). An advanced age and greater number of missing teeth are associated with lower MoCA test scores. No statistical significant correlation with regard to periodontal disease and MoCA test scores.

Conclusion: Based on the preliminary data, positive correlation was confirmed when the number of missing teeth and cognitive skill were assessed. Therefore, larger, multi-center regional surveys are needed to investigate further this relationship.

1. Introduction

According to the General Authority for Statistics in the Kingdom of Saudi Arabia, in 2017, the number of persons aged ≥60 years in Riyadh was 254 216, representing 5% of the overall Saudi population in Riyadh city. Males were (53.6%) and (46.4%) were females (GAS, 2019). Studies have shown that the number geriatric population ≥60 years, worldwide, will increase to 1 in 5 persons by 2050, as projected by the United Nations, (2017). Many elderly people may develop Mild cognitive impairment (MCI), which is a status of early memory loss for expected age or it is defined as early stage of Alzheimer disease, and not fulfill the criteria of Alzheimer disease (Petersen et al., 2001).

There is no cure for cognitive impairment, but the management mainly to address of the patients' symptoms, attempting to improve the way they life and that of their family members. Therefore, it is essential to recognize the factors that may play role in developing MCI in order to postpone the deterioration in the cognitive ability of individual. The fact that, cognitive function deterioration is linked with aging, neurobiological, psychological, and social factors are known fact. Furthermore, other factors like level of education, chronic illness, sedimentary life style, depression and insufficient diet have also been investigated in literature (Backman et al., 2001; Gerstorf et al., 2006; Habib et al, 2007; Nilsson et al., 1997).

It has been reported that, the Saudi population are aging, as well as having high incidence of dental caries, which would result in an increasing demand for oral care (Al-Shehri, 2012). Yet there are limited public health policy or interventions focusing on this group of Saudi population (Al-Shehri, 2012). These issue should addressed by directing a robust community dental health services for older people (Al-Shehri, 2012).

There are increasing evidences that suggest one of the potential risk factor for cognitive impairment is oral health negligence (Okamoto et al., 2010; Reyes-Ortiz et al., 2013; Stein et al., 2007). Earlier studies have investigated the association of cognitive decline number of extracted teeth (Okamoto et al., 2010; Naorungroj et al., 2015), periodontal disease (Noble et al., 2009; Naorungroj et al., 2015) and impaired chewing ability (Kamiya et al., 2016; Momose et al., 1997; Mummolo et al., 2014; Ono et al., 2010; Teixeira et al., 2014).

According to animal studies, the rationale behind relating tooth loss and impaired masticatory ability, is the neuroanatomical and chemical changes that happen in the brain as a result of the reduction in sensory input and cortical blood flow (Kamiya et al., 2016; Teixeira et al., 2014). Parallelly, tooth loss will result in the reduction of the periodontal mechanoreceptors' (the sensory receptors around the teeth) input from the trigeminal nerve. This may subsequently affect the hippocampus-dependent cognitive function (Jacobs and van Steenberghe, 2006).

Periodontal disease and periodontal inflammatory blood markers have also been related to cognitive impairment (Noble et al., 2009). Additionally, studies have linked dental status to nutritional intake and have established a correlation of low dietary intake with a high risk of cognitive decline (Dominguez and Barbagallo, 2017; Gómez-Pinilla, 2008).

Up to our knowledge there is no national survey screening for oral health of Saudi geriatric population and its co-relation to their cognitive status. The objectives of this multicenter cross-sectional study were to investigate if there is a correlation between the number of extracted teeth, periodontal status and cognitive ability in the city of Riyadh-KSA. We aimed to enhance the public awareness about conservative oral health care from an early age.

2. Methods

2.1. Study design

This research was authorized by the Dental Faculty Ethical Review Board (DERB) at King Saud University, and it complied with the guidelines associated to the "Research Ethics on Living Organisms" issued by Royal Decree no. M/29 and with the World Medical Association's Declaration of Helsinki. Written informed consent was once bought from each candidate before their participation in the find out about.

A pilot cross sectional survey targeting geriatric population ≥60-years-old was undertaken at different centers in Riyadh City, Kingdom of Saudi Arabia, which included King Khalid University Hospital (KKUH), King Salman Social Center (KSSC), Social Welfare Home for the Elderly and home visit for Alzheimer's patients in collaboration with Saudi Alzheimer's Disease Association (SADA). Oral examination and Montreal Cognitive Assessment (MoCA) were carried out to identify factors associated with impaired cognitive function, periodontal health status, and number of missing teeth.

2.2. Montreal Cognitive Assessment (MoCA)

MoCA test Arabic version was used for grading the cognitive state and to estimate the stage, and deterioration of cognitive

impairment (Nasreddine et al., 2005); (see Fig. 1). The later version was validated and its reliability was tested (Abdulrahman and AlGaafary, 2009). The MoCA is a 30-point test given in 10 min to assess various cognitive tasks including: Positioning, Short term memory, Visuospatial ability, Decision-making, Conceptual thinking. Participants with decreased cognitive state were those with MoCA test scores below the usual cutoff level (≤26). We excluded patients with

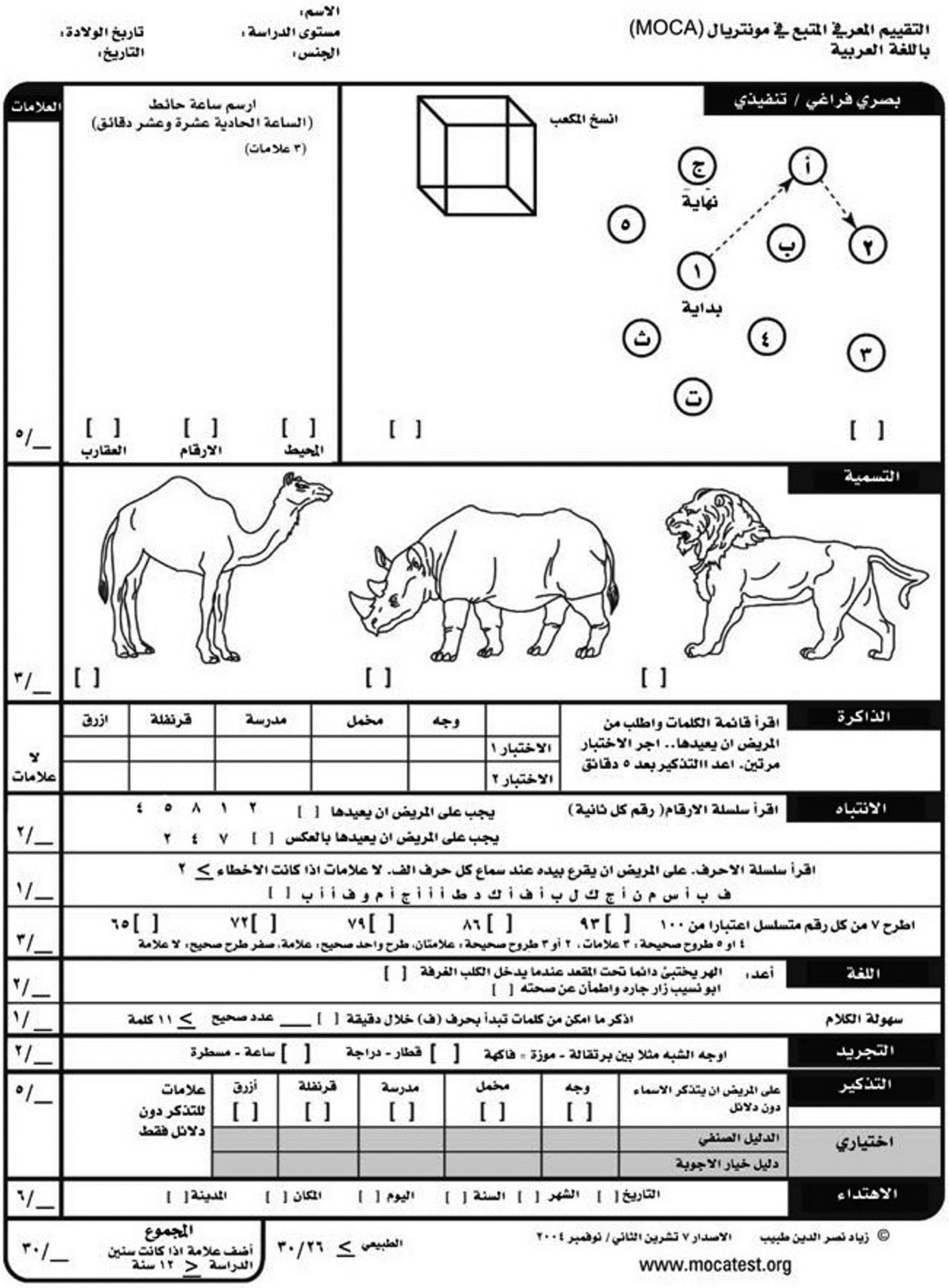

Fig. 1 Montreal cognitive assessment (MoCA) Arabic form.

history of trauma to maxillofacial area, visual or hearing impairment, Brain stroke, and history of severe psychological traumatic memories/ or and sever cognitive decline (Alzheimer cases). All investigators were trained by psychiatrists at KKUH to conduct MoCA test.

2.3. Oral examination

Periodontal condition was examined in the participants using (CPI) (Ainamo, 1982). CPI consist of 4 categories, (CPI 0) healthy, (CPI 1) bleeding on probing, (CPI 2) calculus or dental plaque in the periodontal pocket; (CPI 3) 4–5 mm pocket depth and (CPI 4) ≥6 mm pocket depth. Six measurements per tooth was taken to assess the average pocket depth (two teeth in each quadrant) using a disposable dental/oral examination kit and sterile periodontal probes.

The extracted teeth were calculated, and the status of remaining teeth were assessed as healthy or carious. The remaining roots tip and very loose teeth were excluded. The age at which the teeth were lost was also reported to make sure that all the teeth were lost before the onset of cognitive impairment, data was collected in dental chart (Fig. 2).

2.4. Other variables

Data on sociodemographic characteristics including participants' age, gender, medical history, race, income, educational level, living conditions, occupation, and degree of socialization obtained from the participants or their guardians by face-to-face interview.

2.5. Statistical analysis

The statistical analyses had been carried out using IBM SPSS Statistical software for Windows version 21.0 (IBM Corp., Armonk, N.Y., USA). Mean and standard deviation were calculated for the continuous variable, whereas, frequency used to be generated for the specific variables. Chi-square test was used to compare the qualitative data. Pearson's correlation coefficients have been used to learn about the interrelations of age, periodontal disease, variety of missing teeth with MoCA whole scores. A p-value used to be set at <0.05 for statistically vast distinction for the study values.

3. Results

100 geriatric participant were examined, 5 participants with positive history of dental and head trauma were excluded. 95 participant was the final sample size, 57 (60%) were male and 38 (40%) were female. The mean age was 65.67 ± 6.32 years (male = 64.84 ± 5.16 years; and female = 65.0 ± 6.96 years). Fifty-six of the participants (59%) had cognitive decline. Cognitive decline was significantly more in females than in males ($P < 0.001$), with significant increase in prevalence with advanced age ≥80 years ($P < 0.001$) as shown in (Table 1 and Figs. 3 and 4).

Seventy-nine (83%) of the participants had positive past medical history. However, there were no significant associations between having any form of past medical history and cognitive decline. Most of the participants 60 (63%) belonged to the middle region of Saudi Arabia, while 19 (20%), 9 (10%), and 7 (7%) belonged to the south, north, and west regions, respectively. Eighty-seven (92%) of the participants reported having friends and social networking (Table 1).

Data showed an association between cognitive function and different income, educational, and occupation groups ($P < 0.001$). Twenty-six (79%) of the lower income group had cognitive decline, while 28 (74%) of the higher income group were reported to be cognitively intact. Similarly, cognitive decline were found in 19 (95%) participants with low educational level, whereas in 13 (87%) of the highly educated participants, cognition was intact. Likewise, 41 (79%) of the unemployed showed cognitive decline, while 21 (62%) of the retired participants were cognitively intact (Table 1 and Figs. 5–7).

Interestingly, we found statistically significant moderately negative correlation between age ($r = -0.508$), number of extracted teeth ($r = -0.386$) and the MoCA test scores ($P < 0.001$). Increased age and the extracted teeth were corrolated with lower MoCA scores, which indicated more cognitive decline (Table 2, 3, and Fig. 8).

The result also revealed that 32 (39.0%) participants were periodontally healthy. On the other hand, periodontitis affected 51 (61.0%) participants with 36 (43.4%) showing shallow pocket depth (4–5 mm), and 15 (18.1%) showing deep pocket depth ≥6 mm. However, periodontal health and MoCA test were not correlated in this study ($r = -0.105$, $P = 0.344$) as shown in (Table 2 and Fig. 9).

4. Discussion

This multicenter study was conducted to evaluate the association between tooth loss, periodontal disease, and the presence of cognitive decline in elderly people aged ≥60 years, in the city of Riyadh, KSA.

The study data showed statistically significant relation between cognitive decline and the number of missing teeth. The percentage of participants with cognitive decline increased steadily with increasing number of missing teeth. A moderately negative correlation was found between MoCA test scores and the number of missing teeth. Our data is supported by literature in both animals and human patients which reported the presence of a significant association between poor oral hygiene (manifested by periodontitis and tooth loss) and impairment of cognitive skill (Grabe et al., 2009; Kamer et al., 2009; Kato et al., 1997; Kaye et al., 2010; Makiura et al., 2000; Minn et al., 2013; Okamoto et al., 2010; Oue et al., 2013; Saito et al., 2013; Wu et al., 2008; Yamazaki et al., 2008). Okamoto et al., (2010) found a direct association between number of edentulous spaces and cognitive decline. With regard to risk factors for poor cognition, Reyes-Ortiz et al., (2013) concluded that an edentulous period of more than fifteen years was count as a risk. Matthews et al., (2011) suggested that the loss of 6 to sixteen teeth or more were found in patient with sever cognitive decline. Additionally, Nilsson et al., (2018) concluded that number of missing teeth and alveolar bone resorption have statistically significant association with the outcome of Mini-Mental State Examination (MMSE) score.

The exact mechanism that links number of extracted teeth with decreased cognitive skills is not concluded. The associa-

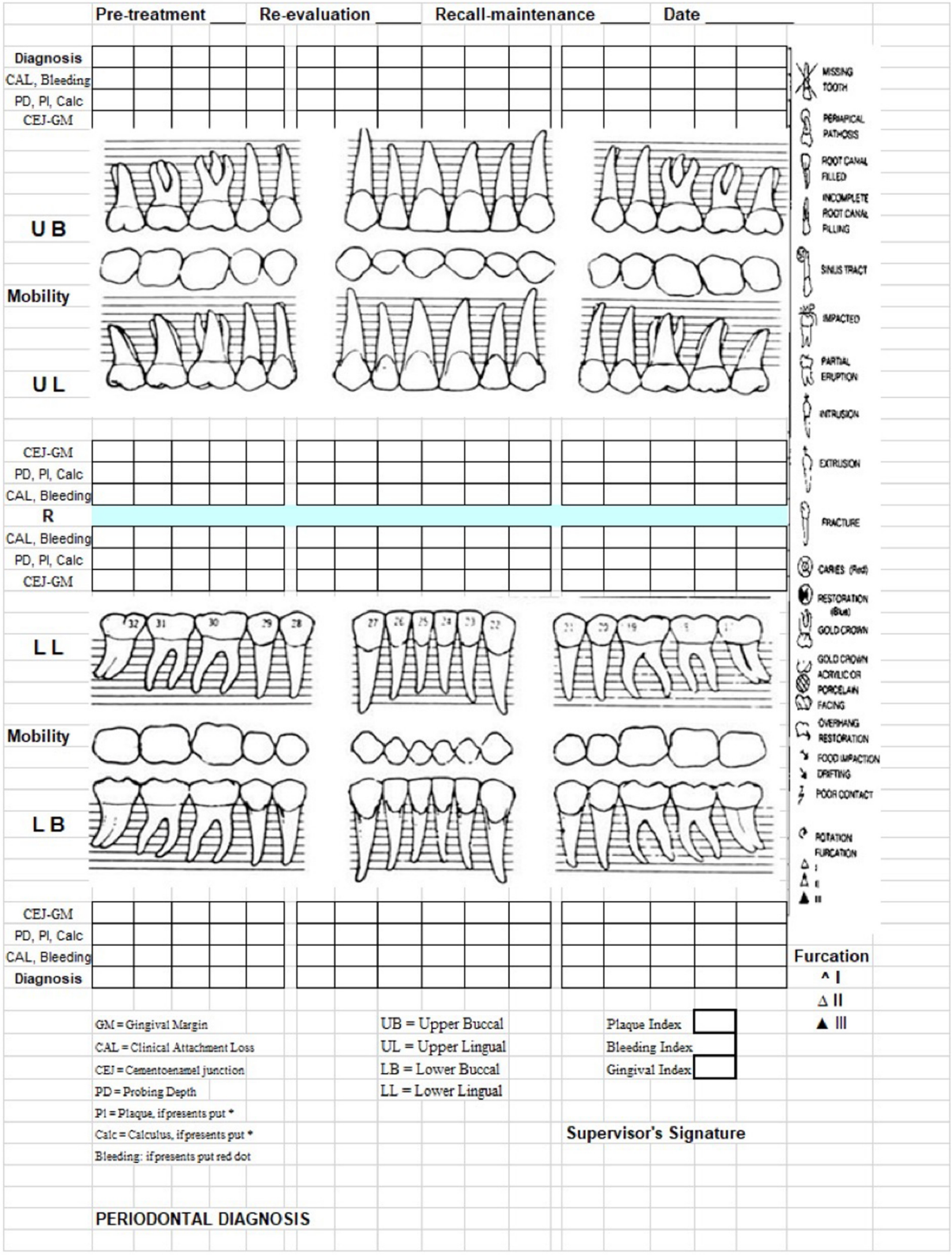

Fig. 2 Shows dental and periodontal chart form used during data collection for all study candidate.

tion between poor oral hygiene and tooth loss on one side and cognitive decline on the other may be of a bi-directional nature. Poor cognitive function in Alzheimer disease (AD) can cause periodontitis and poor oral hygiene (with the ultimate result of tooth loss) due to inability to clean their teeth and obey to oral hygiene instructions or to visit regularly the dentist for professional care (Chalmers et al., 2002; Chalmers and Pearson, 2005; Ellefsen et al., 2009; Ghezzi and Ship, 2000;

Table 1 Sociodemographic characteristics of the total sample and subgroups.

Study Variables	Cognitive Intact (n = 39)	Cognitive Decline (n = 56)	Total (n= 95)	*P*-Value	X^2
Age (years)					
M ± SD	62.87 ± 4.01	67.63 ± 6.9	65.67 ± 6.32	< 0.003	11.58
60–69	35 (52%)	33 (49%)	47 (49.5%)		
70–79	4 (20%)	16 (80%)	21 (22.1%)		
≥ 80	0 (0%)	7 (100%)	16 (16.8%)		
Gender					
Male	25 (66%)	14 (25%)	57 (60%)	< 0.001	16.02
Female	13 (34%)	43 (75%)	38 (40%)		
Past Medical History					
Yes	31 (39%)	48 (61%)	79 (83%)	0.43	0.64
No	8 (50%)	8 (50%)	16 (17%)		
Race					
Middle	27 (45%)	33 (55%)	60 (63%)	0.66	1.58
North	4 (44%)	5 (57%)	9 (10%)		
South	6 (32%)	13 (68%)	19 (20%)		
West	2 (27%)	5 (71%)	7 (7%)		
Income (per month)					
< 2,500 SR	3 (20%)	12 (80%)	15 (16%)	< 0.001	28.17
2500–5000 SR	1 (11%)	8 (89%)	9 (10%)		
5000–10,000 SR	7 (21%)	26 (79%)	33 (35%)		
> 10,000 SR	28 (74%)	10 (26%)	38 (40%)		
Educational Level					
Illiterate	1 (5%)	19 (95%)	20 (21%)	< 0.001	30.05
Primary	5 (22%)	18 (78%)	23 (24%)		
Intermediate	9 (50%)	9 (50%)	18 (19%)		
Secondary	5 (56%)	4 (44%)	9 (10%)		
Diploma	6 (60%)	4 (40%)	10 (11%)		
University	13 (87%)	2 (13%)	15 (16%)		
Occupation					
Current worker	7 (75%)	2 (25%)	9 (9%)	< 0.001	19.78
Retired	21 (62%)	13 (38%)	34 (36%)		
Unemployed	11 (21%)	41 (79%)	52 (55%)		
Social Network					
Yes	38 (44%)	49 (56%)	87 (92%)	0.086	2.94
No	1 (13%)	7 (88%)	8 (8%)		

X^2: Chi square test, M: mean, SD: standard deviation.

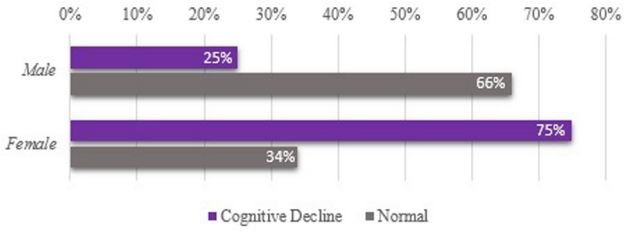

Fig. 3 Presence of cognitive decline in different gender groups ($P < 0.001$, $X^2 = 16.02$).

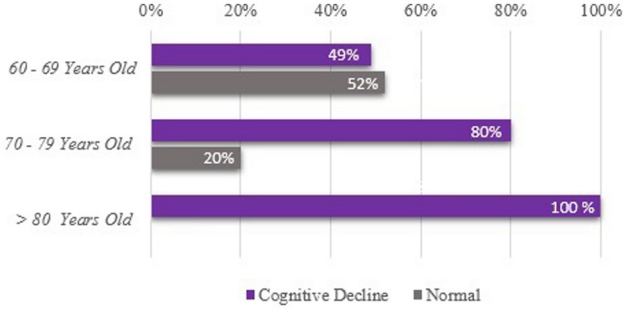

Fig. 4 Presence of cognitive decline in different age groups ($P < 0.003$, $X^2 = 11.58$).

Henriksen et al., 2005; Rejnefelt et al., 2006; Wu et al., 2008) Moreover, poor oral hygiene can contribute to poor cognitive function as well.

First, in 50% of geriatric population the loss of teeth mainly due to periodontal disease. Chronic periodontitis can trigger systemic inflammatory response that could accelerate brain inflammation (Kamer et al., 2008; Watts et al., 2008). Several mediators (such as C-reactive protein, interleukin-1 and 6 and tumor necrosis factor α) are increased in chronic periodontitis (Batty et al., 2013; Holmes and Cotterell, 2009;

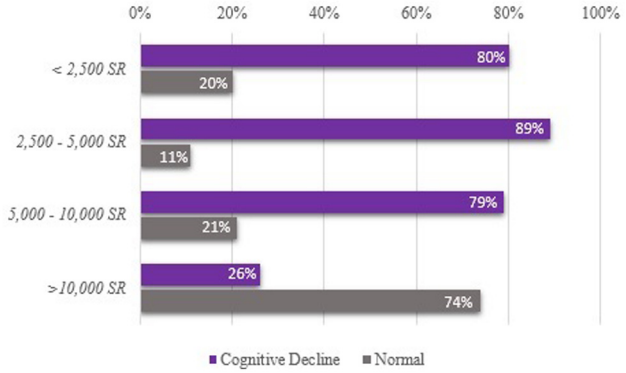

Fig. 5 Presence of cognitive decline in different income groups ($P < 0.001$, $X^2 = 28.17$).

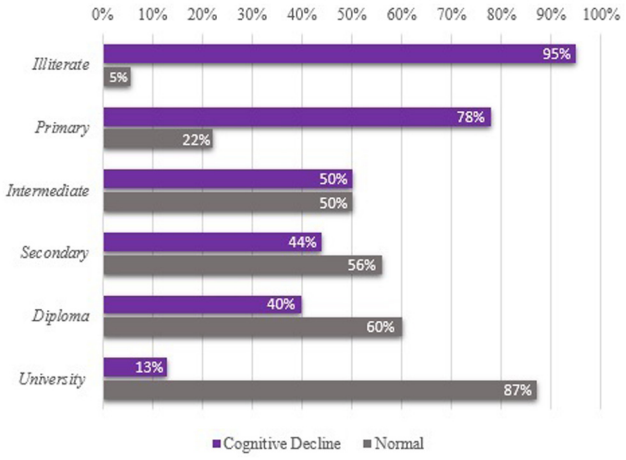

Fig. 6 Presence of cognitive decline in different education groups ($P < 0.001$, $X^2 = 30.05$).

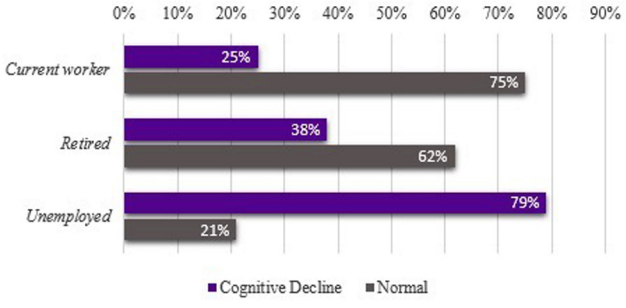

Fig. 7 Presence of cognitive decline in different occupations ($P < 0.001$, $X^2 = 19.78$).

Kamer et al., 2008, 2012; Kaye et al., 2010). There was evidence in literature linked the presence of C-reactive protein to periodontitis showed that an inflammation may activate primed microglial cells within the brain and accelerate the neurodegeneration process in a susceptible individual (Paraskevas et al., 2008). A keystone pathogen-*Porphyromonas gingivalis* for chronic periodontitis was recognized and claim to play role for developing Aβ plaques, cognitive decline, and Alzheimer's disease (Sabbah and Sheiham, 2010), this my infer that *P. gingival* may reach brain systematically which considered a risk factor for Alzheimer's disease . However, our data showed no significant correlation exist between CPI and MoCA test scores.

Table 2 Correlation coefficient between age, number of missing teeth, periodontal health and MoCA test score.

Study Variable	*r*	*P*- value	Interpretation
Age	−0.508	< 0.001	Moderate negative correlation
No. of missing teeth	−0.386	< 0.001	Moderate negative correlation
CPI	−0.105	0.344	weak negative correlation

r: Correlation coefficient, CPI: community periodontal index.

Second, a diminished periodontal mechanoreceptor sensory input and afferent impulses from the masticatory muscle occur by tooth loss. Animal studies showed that tooth loss weakens the memory (Yamazaki et al., 2008). This was explained by the association between weakened memory and reduced sensory input from periodontal mechanoreceptor nerves and muscles of mastication following poor chewing process and tooth loss. This is thought to decrease the number of pyramidal cells in the brain and acetylcholine levels in the hippocampus, resulting in deterioration of memory and learning (Kato et al., 1997; Makiura et al., 2000; Yamamoto and Hirayama, 2001; Yamazaki et al., 2008). Furthermore, to this, it has been found that human artificial teeth result in loss of the sensory input to the brain due to the loss of mechanoreceptor nerves of the periodontal ligament (Hansson et al., 2013). However, it is difficult to confirm these mechanisms because of confounding factors affecting oral health as well as the cognitive decline, for example, age and low socioeconomic status (Borrell and Crawford, 2012; Schmand et al., 1997).

We found a significant correlation of cognitive decline with advanced age and gender. The percentage of participants with cognitive decline increased steadily with advanced age. The MoCA test scores in cognitively decline people correlated significantly and negatively with the participants' age. These findings are in accordance with previous reports showing that the cognitive decline increased with age and prevalent among women (Altmann et al., 2014; Reitz et al., 2011; Ungar et al., 2014).

Among our participants, there was no correlation between cognitive impairment and positive past medical history. This contradicts with the published data on the effect of cardiovascular diseases (Pendlebury and Rothwell, 2009) and diabetes mellitus (Luchsinger et al., 2001) on cognitive function. This controversy may be due to differences in patients' characteristics between the studies, regarding age and the degree of cognitive impairment; and the small sample size in our preliminary survey.

In the present study, cognitive decline was correlated with poor socioeconomic conditions such as low personal income, low level of education, and unemployment. The percentage of participants with cognitive decline increased steadily with decrease in income. These results were consistent with the literature about dementia and cognitive decline. Highly educated elderly people when were reported high score MoCA test than

Table 3 Study groups by number of missing teeth and periodontal health.

Variable	Cognitive Intact (n = 39)	Cognitive Decline (n = 56)	Total (n = 95)	*P*-Value	X^2
No. of missing teeth					
M* ± *SD	6.67 ± 6.36	13.16 ± 9.97	2.24 ± 1,4	< 0.005**	14.7
0–5	23 (64%)	13 (36%)	36 (37.9%)		
6–11	9 (31%)	20 (69%)	29 (30.5%)		
12–17	5 (36%)	9 (64%)	14 (14.7)		
18–23	0 (0%)	3 (100%)	3 (3.2%)		
24–32	2 (15%)	11 (85%)	13 (13.7%)		
CPI					
CPI 0	16 (50%)	16 (50%)	32 (38.6)	0.319	2.28
CPI 3	15 (42%)	21 (58%)	36 (43.4%)		
CPI 4	4 (27%)	11 (73%)	15 (18.1%)		

X^2: Chi square test, CPI: community periodontal index.
**: statistically significantat at p value < 0.005

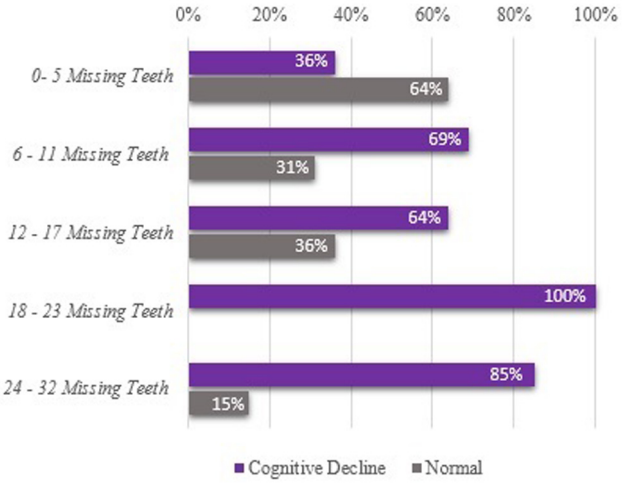

Fig. 8 Presence of cognitive decline by number of missing teeth groups ($P < 0.005$, $X^2 = 14.7$).

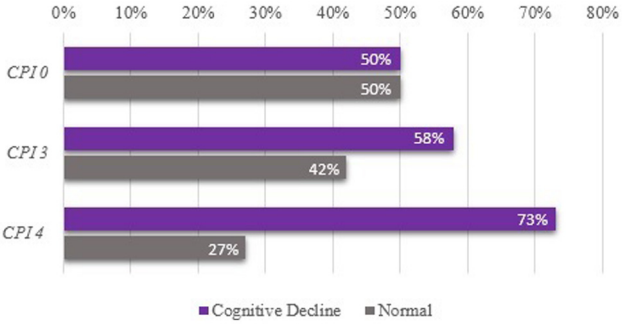

Fig. 9 Presence of cognitive decline by periodontal health ($P = 0.319$, $X^2 = 2.28$).

non-educated (Carlson et al., 2008; Fratiglioni and Wang, 2007).

The correlation between unemployment and cognitive decline may ranked to decreased physical activity among unemployed individuals. This explanation is supported by previous results that reported that, the reduced physical activity was related to a decline in cognitive skill of the study candidate (Okamoto et al., 2010; Tabbarah et al., 2002). In addition, individuals with low level of education are expected to be unemployed. Low income may also lead to inability to obtain healthy adequate diet or seek good education, subsequently resulting in nutritional deficiencies and poor or no education (factors which contribute to cognitive impairment).

Some studies have attempted to adjust for the poor socioeconomic conditions and age while exploring the relation between tooth loss/oral hygiene and memory decline. Wu et al., (2008) investigated the patients' sociodemographic factors and individual dental care were strongly correlated. They concluded that the decrease in the cognitive skill scores was significantly correlated with worsened oral health, after considering variables like race, age and gender. In addition, Okamoto et al., (2010) tested the relation between the number of extracted teeth, individual's socialization and cognitive skills, they found a significant correlation were existing. The later study was considering many variables like age, gender and education. On the other hand, Matthews et al., (2011) conducted an adjusted analysis for sociodemographic factors that revealed there was no correlation between extracted teeth and cognitive skills. Lexomboon et al., (2012) found that, cognitive impairment was not significantly associated with individuals who had tooth loss and those without when the common variables were adjusted (e.g. sex, age, and education). However, they have reported a strong correlation between cognitive impairment and the chewing ability of elderly patient (Lexomboon et al., 2012).

The current study has some points of strength. It is the first study of its kind in KSA and participants were recruited from the different regions of the city of Riyadh. Also, sociodemographic factors of the participants were thoroughly evaluated. Cognitive function and gingival status were evaluated using objective scoring systems. However, the study was prone to some limitations. The cross-sectional design did not provide the required data to assess for potential causal relationship between impaired cognitive function in people with Alzheimer's disease and loss of teeth. The limitation of small sample size may hinder the generalization of the results.

We concluded from our preliminary data that, a significant relationship between number of extracted teeth and cognitive decline in our study group. We recommend the conduction

of prospective cohort studies that could examine this suggested causal relationship from larger sample size in a multiregional study.

Role of the funding source

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical approval

The ethical approval and facilitating latter of this study were obtained from DERB at King Saud University (ethic approval no. E-17-2627 dated 29.11.2017).

Patient consent

A written informed consent was obtained from all the participants who participated in this study.

Declaration of Competing Interest

The authors declare no conflict of interest.

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