RESEARCH

EVALUATION OF THE RELATIONSHIP BETWEEN ORAL HEALTH, CHEWING ABILITY, AND DEGREE OF DISEASE IN ALZHEIMER-TYPE DEMENTIA PATIENTS

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Abstract

Introduction: The objective of this study was to investigate the relationship among oral health attitudes, chewing efficiency, and the degree of disease in patients with Alzheimer-type dementia.

Materials and Methods: Thirty-nine patients with Alzheimer-type dementia as the study group and 38 cognitively healthy participants as the control group were registered for this cross-sectional study. The participants' demographics and basic clinical features, oral health attitudes, and chewing efficiency scores were recorded for the analysis, and then the evaluation was done comparatively between the groups.

Results: A total of 77 participants were included the study. The mean ages of the healthy (control) and Alzheimer-type dementia (study) groups were determined as 69.28 ± 3.31 and 67.10 ± 2.11 years, respectively. The chewing scores of the healthy and Alzheimer-type dementia groups were compared, and the scores of Alzheimer-type dementia group showed significantly lower values than the scores of the healthy group ($p<0.001$). Not using dentures despite tooth loss for both the mandibula and maxilla was found to be significantly higher in the Alzheimer-type dementia group than it was in the healthy group ($p<0.001$).

Conclusion: The study showed a negative correlation between oral health attitudes, chewing efficiency, and the degree of disease in patients with Alzheimer-type dementia. Poor chewing efficiency may be related to the progress of Alzheimer-type dementia. Healthy chewing functions can support cognitive abilities. Thus, prosthetic treatment can be considered a protective factor against Alzheimer-type dementia.

Keywords: Alzheimer Disease; Dementia; Mastication; Oral Health; Tooth Loss.

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INTRODUCTION

Dementia is a persistent and mostly progressive disease. As it progresses, the disease damages the central nervous system (CNS), and eventually, patients cannot maintain daily life activities because of severe impairment of cognitive areas in the CNS (1). Alzheimer-type dementia (AD) is a well-known type of dementia, and it is the most frequently diagnosed dementia type in elderly patients (2). Atrophy, intercellular amyloid plaques, extracellular senile plaques, and neurofibrillary tangles in the cerebral cortex are neuropathological findings of the disease (3). Disability in cognitive functions and loss of sensory-motor functions are well-known symptoms of AD (2). Although modifiable risk factors have been reported to maintain cognitive ability, the etiopathogenesis of AD has not yet been exactly clarified, and its prevalence continues to increase (1). It is estimated that the number of patients with AD worldwide will reach approximately 66 million by 2030 and 115 million by 2050 because of the increasing elderly population (4). Although the disease is one of the leading causes of morbidity and mortality, a definitive treatment has not yet been found.

Researchers have sought to determine the effects of various factors on the risk of developing AD. In previous epidemiological studies, high education levels, antioxidants (especially vitamin E), use of anti-inflammatory therapy, and mental and physical activities have been reported as protective factors against the disease (5). Conversely, some factors can increase the disease risk. Older age, family history, vitamin B12 deficiency, hormonal factors, and psychosocial factors (low education level, psychosocial activity deficiency, being unable to read or write, etc.) have been defined as common risk factors of the disease (1,5).

In addition to the other factors mentioned above, researchers have begun to investigate the effect of oral health status on AD in various countries. Oral health problems in patients with AD have been found in some studies, and the researchers suspected that the progression of AD could lead to poor oral health status (6). Periodontal diseases and tooth decay are possible dental problems for patients with AD. Furthermore, poor oral health status has been reported as a probable predisposing factor for AD in various studies. Rogers et al (7). reported that an increase in pro-inflammatory agents occurring because of periodontitis, including such agents as interleukin-1 (IL-1), IL-6, and tumor necrosis factor-α (TNF-α), can contribute to cognitive impairment. Similarly, in their study, Aragón et al (8) observed that patients with AD had qualitatively deteriorated saliva and poorer oral health with oral mucosa lesions. In an experimental animal study, the impact of a natural tooth deficiency on cognitive skills was examined, and it was found that the number of pyramidal cells in the hippocampus and gyrus dentate decreases over time after tooth loss, leading to impairment of spatial learning and memory (9). Therefore, impaired chewing function may be related to changes in the cognitive area of the brain (10). Former studies have investigated the correlation between chewing ability and AD, but the outcomes of these studies are not coherent (10,11). Because of the different methodologies of the studies and many confounding factors, the effect of chewing on the progression of AD has not yet been precisely determined.

Recently, peripheral infectious diseases, including low-level systemic inflammation and periodontitis, have been proposed as potential modifiable etiological factors for AD, suggesting a new therapeutic strategy for preventing or managing the disease (12). Similarly, with an understanding of the effect of chewing ability on AD, we can ask whether prosthetic treatment can be considered as a therapeutic strategy to preclude the disease. The aim of the study was to compare the oral health status of patients with AD and healthy individuals in the same age range in terms of the number of missing

teeth, oral hygiene attitudes, types of dentures, occlusion, and chewing efficiency.

MATERIALS AND METHODS

This cross-sectional study was approved by the local institutional ethics committee (ethical code 2019/295). All participants were informed about the study, and their verbal and written consents were taken. Individuals who did not volunteer to participate in the study, patients who had temporomandibular joint disease, patients who had received new prosthetic treatment in the last year, patients who had psychological disorders, patients who were older than 75 years, and patients with a neurological disorder other than AD were excluded from the study.

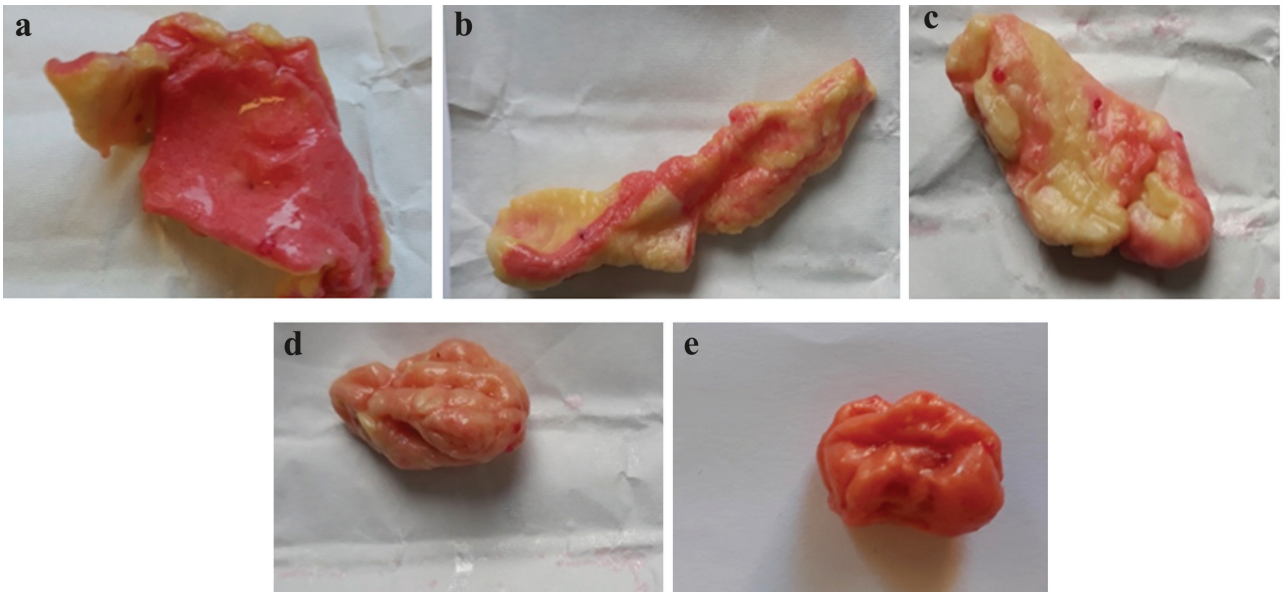
In the study, 39 patients diagnosed with AD were included as the study group and 38 healthy participants without symptoms of AD as the control group. The participants' demographic data were recorded. DSM-IV (Diagnostic and Statistical Manual of Mental Disorders) diagnostic criteria were used to diagnose AD, and a mental status examination of patients was conducted by a neurologist using the Mini Mental Status Examination (MMSE). The MMSE is a practical mental health assessment tool that is frequently used in studies (13,14). There are 11 questions in eight different categories that evaluate patients' orientation ability to time and place, calculation, language, repetition, recall, and responses to complex commands (14). The possible MMSE scores range from 0 to 30. The scores are interpreted as follows: Scores ≥27 represent cognitive health; scores of 22–26 represent mild cognitive impairment; and scores ≤21 represent dementia (13). The cognitive health of each participant was assessed using this instrument, and the degree of AD was defined according to the results. After neurological examination, the participants were directed to the next room for their oral examinations.

Each oral health examination was done by a prosthodontist who did not know the patients' cognitive statuses. In addition, the chewing efficiency of participants was evaluated. Patients were asked questions evaluating oral health and oral hygiene attitudes. After examining the patients' dentures and occlusion, chewing efficiency was evaluated with a double-colored gum chewing test for 40 strokes. While the patient was sitting in an upright position with his head facing forward, the gum was left in the mouth and the participant chewed gum (Vivident). Chewing was not instructed by anyone. Following this, the chewed gum specimens were examined under a light source and ranked with scores of 1 to 5 scores following the mixing ability classification determined by Schimmel et al. (15) (Figure 1). The categories of the scale were as follows:

1. The gum is not mixed completely, and the vomit scar appears once.
2. Large parts of the gum are not fully mixed.
3. The gum is mixed, but the original color appears to be slightly unmixed.
4. The gum is well mixed but does not appear as a single color.
5. The gum appears to have a very well-mixed single color.

Statistical analysis was conducted using the Statistical Package for Social Sciences version 22.0 (SPSS Inc., Chicago, Illinois, USA). Following a similar previous study (16), a priori power analysis indicated that 36 subjects per group would yield a power β = 0.80 and α = 0.05 with a difference of 2 points between groups. The Kolmogorov–Smirnov test was used to control the normal distribution of variables. Mann–Whitney U test was used for the comparison of groups. Chi-square test was used for comparison of the categorical variables between the groups. The Spearman correlation coefficient was used to evaluate the correlation between chewing scores and MMSE scores. Further, the correlation between the MMSE scores and number of missing teeth and the correlation between the MMSE scores and du-

Figure 1. The ranking of chewing scores according to Schimmel et al. study. Degree of chewing efficiency was rated from 1 to 5 (a-e).



a.: Score-1. The gum was not mixed completely and the vomit scar appeared once. **b. :** Score-2. Large parts of the gum are not fully mixed. **c.:** Score-3. The gum is mixed, but the original color appears to be slightly unmixed. **d.:** Score-4. The gum is well mixed but does not appear as a single color. **e.:** Score-5. The gum appears to have a very well mixed one color.

ration of denture usage were evaluated with the Spearman correlation coefficient. A *p*-value ≤ 0.05 was considered statistically significant.

RESULTS

Seventy-seven participants were included in the study. Evaluations were conducted comparatively between the AD group and the healthy group. The MMSE scores of the participants ranged from 8 to 30. The mean MMSE scores of the healthy (control) and AD (study) groups were 28.47±1.15 and 17.64±0.77, respectively. The mean ages of the healthy and AD groups were 69.28 ± 3.31 and 67.10 ± 2.11 years, respectively. The mean number of missing teeth in the mouth was determined as 23.00 ± 8.41 for the AD group and 12.06 ± 5.26 for the healthy group. When the dentures usage periods of the groups were evaluated, the mean time was determined to be 9.28 ± 8.51 years for the AD group and 4.15 ± 2.36 years for the healthy group. In addition, the time after last tooth extraction was evaluated in both groups, and the mean times were determined as 14.66 ± 10.07 years in the AD group and 4.42 ± 2.44 years in the healthy group.

The demographic data of the participants in the study, their oral health attitudes, their oral health product preferences, their dentures types, and their occlusion were comparatively evaluated using the chi-square test. The results are shown in Tables 1, 2, and 3. Education level, the reason for going to the dentist, the frequency of going to the dentist, and the frequency of teeth/dentures cleaning indicated significant differences between the healthy group and the AD group ($p<0.001$). When the products used for oral hygiene were evaluated, significant differences were observed between the two groups in terms of the use of a toothbrush, toothpaste, dental floss, soap, and denture cleaning brush ($p<0.001$). Use of oral hygiene products was signifi-

Table 1. Distribution of the participants according to demograhic and oral health attitudes.

Variables		Total (%)	Cognitively Healthy (%)	AD (%)	p-value
Gender	Female	37 (48.1)	17 (44.7)	20 (51.3)	0.729
	Male	40 (51.9)	21 (55.3)	19 (48.7)	
Education	Illiterate	28 (36.4)	4 (10.5)	24 (61.5)	**<0.001**
	Primary school	31 (40.3)	20 (52.6)	11 (28.2)	
	High school	18 (23.4)	14 (36.8)	4 (10.3)	
	College	0 (0)	0 (0)	0 (0)	
Reason to Dentist Visit	Regular control	10 (13)	10 (26.3)	0 (0)	**<0.001**
	Pain or problem	67 (87)	28 (73.7)	39 (100)	
How often have you visited the dentist in the last 5 years?	Once times a year	2 (2.6)	0 (0)	2 (5.1)	**<0.001**
	2 times a year	22 (28.6)	17 (44.7)	5 (12.8)	
	3-4 times a year	12 (15.6)	8 (21.1)	4 (10.3)	
	Never	41(53.2)	13(34.2)	28(71.8)	
What is your opinion about your oral health?	Very good	1 (1.3)	0 (0)	1 (2.6)	0.600
	Good	26 (33.8)	14 (36.8)	12 (30.8)	
	Medium	31 (40.3)	14 (36.8)	17 (43.6)	
	Poor	19 (24.7)	10 (26.3)	9 (23.1)	
	Very poor	0 (0)	0 (0)	0 (0)	
Frequency of teeth/ denture cleaning?	More than 3 times in a day	1 (1.3)	0 (0)	1 (2.6)	**<0.001**
	2-3 times in a day	14 (18.2)	3 (7.9)	11 (28.2)	
	One times in a day	35 (45.5)	24 (63.2)	11(28.2)	
	One times in a week	13 (16.9)	11 (28.9)	2 (5.1)	
	Sometimes	3 (3.9)	0 (0)	3 (7.7)	
	Never	11 (14.3)	0 (0)	11 (28.2)	

Data are shown as Mean ±Std.Dev. and compared by Chi Square test. *p<0.05, statistically significant.

Table 2. The frequency of oral hygiene products which used by the participants.

Oral Hygiene Products		Total (%)	Cognitively Healthy (%)	AD (%)	p-value
Manual toothbrush	Yes	64 (83.1)	38 (100)	26 (66.7)	**<0.001**
	No	13 (16.9)	0 (0)	13 (33.3)	
Electronic toothbrush	Yes	0 (0)	0 (0)	0 (0)	–
	No	77 (100)	38 (100)	39 (100)	
Toothpaste	Yes	33 (42.9)	30 (78.9)	25 (64.1)	**<0.001**
	No	44 (57.1)	8 (21.1)	14 (35.9)	
Oxyjet	Yes	0 (0)	0 (0)	0 (0)	–
	No	77 (100)	38 (100)	39 (100)	
Dental Floss	Yes	22 (28,6)	21 (55.3)	1 (2.6)	**<0.001**
	No	55 (71,4)	17 (44.7)	38 (97.4)	
Superfloss	Yes	0 (0)	0 (0)	0 (0)	–
	No	77 (100)	38 (100)	39 (100)	
Interdental brush	Yes	0 (0)	0 (0)	0 (0)	–
	No	77 (100)	38 (100)	39 (100)	
Mouthrinse	Yes	6 (7.8)	2 (5.3)	4 (10.3)	0.675
	No	71 (92.2	36 (94.7)	35 (89.7)	
Soap	Yes	33 (42.9)	30 (78.9)	3 (7.7)	**<0.001**
	No	44 (57.1)	8 (21.1)	36 (92.3)	
Denture Cleaning Brush	Yes	8 (10.4)	8 (21.1)	0 (0)	**0.02**
	No	69 (89.6)	30 (78.9)	39 (100)	
Tongue Cleaning Brush	Yes	0 (0)	0 (0)	0 (0)	–
	No	77 (100)	38 (100)	39 (100)	

Data are shown as Mean ±Std.Dev. and compared by Chi Square test. *p<0.05, statistically significant.

Table 3. Description of the participants according to type of denture and occlusion.

Type of Denture		Total (%)	Cognitively Healthy (%)	AD (%)	p-value
Maxilla	Kennedy III and IV removable partial denture	21 (27.3)	20 (52.6)	1 (2.6)	**<0.001**
	Kennedy I and II removable partial denture	15 (19.5)	14 (36.8)	1(2.6)	
	Complete denture	23 (29.9)	2 (5.3)	21 (53.8)	
	Natural dentition	1 (1.3)	1 (2.6)	1(2.6)	
	Fixed Partial denture	4 (5.2)	1 (2.6)	3 (7.7)	
	Implant retained fixed denture	0 (0)	0 (0)	0 (0)	
	Implant retained removable denture	1 (1.3)	0 (0)	1(2.6)	
	No denture, no natural dentition	12 (15.6)	1 (2.6)	11 (28.2)	
Mandibula	Kennedy III and IV removable partial denture	21 (27.3)	14 (36.8)	7 (17.9)	**<0.001**
	Kennedy I and II removable partial denture	21 (27.3)	20 (52.7)	1 (2.6)	
	Complete denture	16 (20.8)	1 (2.6)	15	
	Natural dentition	3 (3.9)	2 (5.3)	1 (2.6)	
	Fixed Partial denture	0 (0)	0 (0)	0 (0)	
	Implant retained fixed denture	0 (0)	0 (0)	0 (0)	
	Implant retained removable denture	1 (1.3)	0 (0)	1 (2.6)	
	No denture, no natural dentition	15 (19.5)	1 (2.6)	14 (35.9)	
Occlusion	Canine guided occlusion	1(1.3)	0 (0)	1 (2.6)	**<0.001**
	Group guided occlusion	40 (51.9)	37 (97.4)	3 (7.7)	
	Bilateral balanced occlusion	20 (26)	1 (2.6)	19 (48.7)	
	Lingualized occlusion	0 (0)	0 (0)	0 (0)	
	There is no occlusion relationship	16 (20.8)	0 (0)	16 (41)	

Data are shown as Mean ±Std.Dev. and compared by Chi Square test. *p<0.05, statistically significant.

cantly higher in the healthy group than it was in the AD group ($p<0.001$). When the types of dentures in the mandibula and maxilla were evaluated, significant differences were defined between the groups ($p<0.001$). Not using dentures despite tooth loss for both the mandibula and maxilla was found to be significantly higher in the AD group compared with the healthy group. Similarly, the use of complete dentures for both mandibula and maxilla was significantly higher in the AD group than it was in the healthy group ($p<0.001$). When the occlusal relations of both groups were compared, the rates of absence of occlusal relations and bilateral balanced occlusion were found to be significantly higher in the AD group ($p<0.001$).

The chewing ability of the participants was assessed using two-colored gum. The chewing scores were ranked according to mixing rates of the gum specimens according to Schimmel et al.'s study (15) (Figure 1). The chewing scores of the healthy and AD groups were comparatively evaluated, and the scores of the AD group showed significantly lower values than the scores of the healthy group ($p<0.001$; Table 4). The correlation between the participants' MMSE scores and chewing efficiency scores was evaluated using the Spearman correlation coefficient. A significant positive correlation was found between the two variables ($r = 0.741$, $p<0.001$). In addition, a significant negative correlation was found between the MMSE scores and the number of missing teeth ($r = 0.485$, $p<0.001$) with the evaluation of the Spearman correlation coefficient. However, there was no defined significant correlation between the MMSE scores and the time of denture usage ($r = 0.031$, $p=0.786$).

DISCUSSION

This study comparatively evaluated chewing efficiency, oral health attitudes, and dentures in terms of cognitive health. The most prominent result of the study was that healthy patients presented better findings in terms of chewing efficiency, oral health awareness, and attitudes compared with those diagnosed with AD.

In previous studies on this topic, patients were mostly aged 75 years or higher (3,16). In contrast, in our study, the study population was selected from the group of patients aged 65–75 years. The participants were younger than patients in the previously researched populations. Because the onset of neuropathological alterations is generally diagnosed in people 65 years or older (1), the study aimed to evaluate the relationship between oral health status and cognitive health in an early age range when AD is first diagnosed. Therefore, the patients who were first consulted in the neurological department were selected for the study, and they had not previously taken any medication for AD. Medicines prescribed for AD can cause oral problems, such as xerosto-

Table 4. Comparison of chewing scores between the groups.

	Chewing Efficiency Score		p-value
	Mean ±Std. Dev.	**Median (25^{th}-75^{th} percentile)**	
Cognitively Healthy Group	3.84±0.43[a]	4 (4 - 4)[a]	**<0.001**
AD Group	2.61±0.74[b]	3 (2 - 3)[b]	

Mean ±Std.Dev. and median (25^{th}-75^{th} percentile). Bold p-values indicate statistical significance at $\alpha<0.001$ for Mann-Whitney U test.
[a,b]Same superscript letter indicates statistically significant difference in the comparison between groups.

mia (17) and this can affect the chewing function of patients; therefore, it was aimed to avoid this confounding factor. Thus, chewing efficiency without the effect of AD medications was evaluated in this study.

Chewing efficiency is different from chewing performance. *Chewing performance* is defined as the distribution percentage of the particle size of the food chewed after a certain number of chewing cycles, whereas *chewing efficiency* is defined as the number of extra strokes required by individuals to reach the grinding level of individuals (18). In this study, two-colored gum was used to evaluate chewing efficiency because this method was easy and convenient, and there is no disintegration of matter that can be deposited under dentures or be swallowed during chewing (19). After chewing, the gum can be easily removed from the oral environment, and it is easy to control in terms of chewing performance. There are studies that have concluded that mixing-based color mixing tests are also more suitable for elderly individuals with poor chewing function (20). Although chewing efficiency was evaluated in the study, the results were in accordance with previous studies that focused on the chewing ability of patients with AD (10,16). The chewing scores of patients with AD were found to be significantly lower compared with the scores of the healthy participants. Furthermore, a positive significant correlation was detected between the participants' MMSE scores and chewing efficiency scores.

Brain regions associated with chewing function can be negatively affected by AD (10) because trigeminal sensory inputs activate the locus coeruleus, which promotes cognitive processes (16). Chewing and occlusal stimulation can affect the received inputs of the locus coeruleus, losing natural teeth and changes in occlusal relations may impair inputs (10). In accordance with this information, a significant negative correlation was found between the MMSE scores and the number of missing teeth in the current study. In a previous study, the loss of teeth showed a negative impact on individuals' cognitive functions (13). AD has been evaluated in terms of the number of natural teeth and occluding teeth units. It has been reported patients with less than nine remaining natural teeth could be at risk of cognitive impairment (21). Similarly, we found that the number of remaining teeth was generally less in the AD group than in the healthy participant group. In addition, occlusal relation findings were better in the healthy participant group than they were in the AD group. In fact, some patients in the AD group did not have any occlusal relation because they were missing all their natural teeth and did not have any type of dentures. Although there were teeth deficiencies in the healthy participant group, they had occlusal relations with their dentures. Thus, the observed differences between the two groups of the study may be considered proof of the effect of occlusal relations on cognitive health, even if it is provided with artificial teeth.

Having natural teeth, missing teeth number or being edentulous or wearing removable dentures is important for chewing. Chewing with removable dentures can be more difficult than fixed dentures because of displacement during functional movements (22). Although denture type has an effect on chewing efficiency, it has been stated that the adaptation of mastication muscles to chewing is time-dependent (23). In this study, the effect of denture type on the chewing efficiency can not comprehensively evaluated because of the number of the patients. But, the effect of the newly made denture on the patient's chewing efficiency was tried to be prevented. Therefore, participants who used their dentures for more than 1 year were included in the study.

The study revealed that the oral health attitudes of healthy participants were better than those of patients with AD. The ability to perform oral hygiene routines can deteriorate because of impaired memory, and therefore, oral health status cannot be maintained properly. Impaired executive function can reduce a person's ability to clean the teeth ef-

fectively by brushing and flossing. However, previous studies have reported different results. In her study, Riberio (24) found no significant difference between healthy participants and participants with AD in terms of oral health. Interestingly, Warren et al (25). stated that the self-perceived oral health of patients with AD in their study was better than that of healthy patients. Different countries and dissimilar health services of countries may be reasons for the inconsistent findings among the prior studies.

A scientific report by the Lancet Commission stated that the risk factors of AD may vary according to country; thus, it is important to evaluate findings from different cultures and environments for strategies to be developed against the disease (1). Similarly, further research from different countries can be important to elucidate the effect of tooth deficiency and chewing function on cognitive health. Previous studies in different countries presented search results from Japan, Spain, and Australia (3,11,17). However, the effect of oral health status and chewing function on cognitive health has not been investigated in some countries. This study is the first research on the topic from Turkey; nevertheless, the results of this study were in accordance with those of former studies. There are some strong points of the study. Including AD patients diagnosed for the first time without the effect of any AD medications is a strong point of the study. Another point is that the prosthodontist who performs the oral examination does not know anything about cognitive status of the patients.

According to the results of the current study, oral health and prosthetic rehabilitation can be considered an important factor when it comes to controlling cognitive deterioration. Although the results of the study emphasize the link between chewing efficiency and AD, this research does have some limitations. The main limitations of the study were its single-center design and that the analyzed data were limited. Participants from different regions could be evaluated in further multi-center clinical studies. Further, another important limitation of the study is that the effect of denture types on chewing efficiency could not be evaluated comparatively, because the number of patients that could be reached in the city where the study was conducted was limited. Comparative evaluation of denture type on chewing efficiency of AD patients should be made in further multicenter studies. In addition, long-term follow-up studies are needed to determine the effect of oral health status and denture type on the progression of AD. Further research from different nationalities and countries should be useful to elucidate the effect of prosthetic treatment on patients' cognitive health. Prosthetic treatment may come to be considered as a protective factor for AD.

CONCLUSION

The current study presented a negative correlation between the degree of disease in patients with AD and chewing efficiency. Clinicians should be aware of the oral treatment needs of patients with AD and the possible effect of chewing inability on the progress of AD.

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Competing interest

The authors declare that they have no conflict of interest.

Statement of Ethics:

The study protocol was approved by the Research Ethics Committee of the Bolu Abant Izzet Baysal University, (ethical code 2019/295). The study was administrated in agreement with the Declaration of Helsinki.

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