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Original Article

A comparative analysis of older patients with chewing difficulties due to temporomandibular disorders and tooth loss

Hye-Mi Jeon [a,b], So-Yeun Kim [c], Yong-Woo Ahn [d,e], Soo-Min Ok [d,e], Sung-Hee Jeong [d,e], Hye-Min Ju [d,e*]

[a] *Department of Oral Medicine, Dental Clinic Center, Pusan National University Hospital, Busan, Republic of Korea*
[b] *Biomedical Research Institute, Pusan National University Hospital, Busan, Republic of Korea*
[c] *Department of Prosthodontics, School of Dentistry, Kyungpook National University, Daegu, Republic of Korea*
[d] *Department of Oral Medicine, Dental and Life Science Institute, School of Dentistry, Pusan National University, Yangsan, Republic of Korea*
[e] *Department of Oral Medicine, Dental Research Institute, Pusan National University Dental Hospital, Yangsan, Republic of Korea*

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KEYWORDS
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Abstract *Background/purpose:* Chewing difficulty can contribute to psychological stress, which reduces the quality of life for older adults. The purpose of this study was to investigate and analyze the severity of masticatory discomfort, stress response, and sleep disturbance in older patients experiencing masticatory discomfort due to tooth loss or temporomandibular disorders (TMD), to find the further treatment direction for these patients.
Materials and methods: A total of 392 patients aged 50 years and older with mastication difficulties were analyzed. Two group of patients, those seeking prosthetic treatment due to tooth loss (n = 193) and those who were referred due to TMD-related pain discomfort (n = 199), were identified. Numeric rating scale (NRS), stress response inventory (SRI), and insomnia severity index (ISI) were used as tools to measure patients' subjective chewing discomfort, stress response, and sleep status.
Results: Chewing discomfort and age were found to be much higher in the prosthetic group than in the TMD group. The TMD group had significantly higher scores in five SRI parameters (tension, anger, depression, fatigue, and frustration) as well as total score and a higher percentage of clinical insomnia compared to prosthetic patients.

* Corresponding author. Department of Oral Medicine, School of Dentistry, Pusan National University Beomeo-ri, Mulgeum-eup, Yangsan, Gyeongsangnam-do, 50612, Republic of Korea.
E-mail address: jc2wma@pusan.ac.kr (H.-M. Ju).

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Conclusion: Since the number of remaining teeth has a significant impact on the masticatory discomfort severity, restoring the occlusion through prosthodontic treatment is important to improve masticatory function. In patients with TMD, it is necessary to assess stress response and sleep quality, and a multidisciplinary treatment approach may be necessary to effectively address masticatory discomfort.

Introduction

One of the main reasons for dental treatment is restoration of oral function. Mastication is the main function of the oral cavity, and it is essential for chewing and swallowing food.[1] The masticatory structures consist of the masticatory muscles, the temporomandibular joint (TMJ), and the occlusion of the teeth. Normal mastication is dependent on the harmony between these structures. The reduced masticatory ability due to tooth loss or temporomandibular disorders (TMDs) has been found to be associated with impairments in digestion, nutrition, social interaction, cognition, and quality of life, especially in older adults.[2,3]

Several studies have reported that chewing ability was found to decrease significantly with an increasing tooth loss. In particular, it has been reported that absent posterior tooth is associated with impaired chewing ability, and loss of these teeth is positively correlated with age.[4–7] TMD-related joint impairment also causes reduced chewing ability. TMD is a collective term for several clinical problems that involve masticatory muscles, TMJ, or both. Pain associated with the masticatory muscles or TMJ during chewing or mouth opening are the most common signs and symptoms of TMD. Age is considered a risk factor for TMD, with older people presenting with a higher prevalence of TMD.[8–11] In a study by Kurita et al.[12] that analyzed factors affecting the score of chewing ability (SCA) in patients with TMD, age was found to be a statistically significant factor, with SCA scores dropping significantly in patients over 50 years of age.

Many studies have reported that TMD and tooth loss are associated with psychological stress. TMD has a complicated multifactorial etiology, and psychological factors play important roles in the generation, development, and outcome of TMD.[13–15] Previous studies have reported that patients with missing or misshapen teeth feel as if they have lost a part of their body, and that the loss and discomfort manifests itself in the form of stress.[16–18]

Moreover, psychological factors can influence sleep quality. Sleep is an essential element of survival, by maintaining homeostasis of physical health and mental functions. A lower quality of sleep can lead to the development of somatization, obsessive compulsive disorder, depression, and anxiety, suggesting that insomnia is highly correlated with psychological problems. In addition, lack of sleep leads to a mentally sensitive state, making it difficult to control emotions and increasing the intensity of pain experienced by the patient.[19,20]

Although, there are studies on the relationship between TMD and stress and sleep quality and the relationship between tooth loss and stress and sleep quality, to our knowledge, comparative studies between the two groups are rare. In this study, we evaluated the patients who complained of chewing difficulty, categorized the them into TMD and tooth loss groups, and compared and evaluated the degree of masticatory discomfort, stress response, sleep quality, and oral condition of each group. Based on these findings, we could suggest treatment approaches for elderly patients who complain of masticatory discomfort based on its cause.

Materials and methods

The research protocol was approved by the Ethics Committee of Pusan National University Hospital (PNUH; approval no. 2009-002-094) and informed consent was obtained.

Study sample

This study was conducted from June 2018 through september 2020. The study included a total of 392 patients aged 50 years and older who visited the Dental Clinic Center at Pusan National University Hospital because they had difficulty chewing. Exclusion criteria were as follows (1) patients with history of facial and jaw fracture, and orthognathic surgery, (2) patients who had a history of psychiatric conditions, (3) patients who had neurologic impairment or diseases (e.g., stroke, tumor, trauma, or epilepsy), (4) patients who had other systemic muscular disorders (e.g., fibromyalgia, rheumatoid arthritis). Patients were categorized into two groups: those seeking prosthetic treatment for tooth loss (193 Prosthetic group) and those referred for discomfort related to temporomandibular joint pain (199 TMD group). The 193 Prosthetic group were free of TMD signs and symptoms. The TMD group consisted of 199 persons, each subjects examined their clinical signs and symptoms based on the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) axis I guidelines.

Assessment of variables

Chewing ability is defined as an individual's own assessment, in this study evaluated the chewing difficulty by use

of numeric rating scale (NRS) from 0 to 10. The number of missing posterior teeth was recorded. The pontic of bridges were considered the same as remaining teeth, but the tooth stump and coping are excluding. The occlusal condition was classfied by using Eichner's index. The Eichner's classification is based on occlusal contact areas in antagonist jaws for the natural dentition, including fixed dentures. Class A equates to contact in all 4 supports zones; this means there is a minimum of one tooth in contact between the maxilla and the mandible in both the premolar and molar regions on each side. Class B contains 3(B1), 2(B2), 1(B3) support zones, or loss of all supporting zones but support in the anterior tooth(B4). In Class C, there are no contact at any support zone.[21]

Questionnaires

Psychological profile and sleep quality were assessed with self-report instruments administered at the initial evaluation. All patients were asked to complete the questionnaires before the diagnosis, and filled them out in the waiting room. Informed written consent was obtains from every patients. The questionnaires were consisted of two parts;

Insomnia

Insomnia was assessed using the Insomnia Severity Index (ISI), a reliable and valid instrument.[22] It has been translated into several languages and used to evaluate insomnia in pain research. A Korean version of the ISI was validated in 2014 by Cho et al.[23] Patients rated each items on a 5-point scale (not at all, 0; Somewhat, 1; Moderately, 2; Very much, 3; Absolutely, 4), and total scores range from 0 to 28, with higher scores indicating more severe insomnia. According to the recommended score interpretation guideline, a total score of 0–7 indicate "grade 0", 8–14 indicate "grade 1", 15–21 indicate "grade 2", 22–28 indicate "grade 3". A cutoff score of 15 has been used as the threshold for clinically significant insomnia, and a score below 8 has been used to define remission after treatment.

Psychological profiles

Psychological profiles were evaluated based on the Stress Response Inventory (SRI). SRI is validate assessment method that has been developed by Ko et al.[24] in Korean to measure of stress levels for research in stress-related field within a short time. It includes seven symptom dimensions: tension subscale (6 items), aggression subscale (4 items), somatization subscale (3 items), anger subscale (6 items), depression subscale (8 items), fatigue subscale (5 items), and frustration subscale (7 items). In total, the questionnaire contained 39 items, each of which was arranged in a Likert-type format: not at all, 0; Somewhat, 1; Moderately, 2; Very much, 3; Absolutely, 4. The global score ranges from 0 to 156, with higher scores indicating more severe stress responses.

Statistical analysis

A normality test for the parameters was performed using the Kolmogorov–Smirnov test. For comparison of the differences between the prosthetic and TMD groups, data were analyzed by the independent *t*-test or the Wilcoxon rank sum test for continuous variables. Chi-square test and Fisher exact test were used for assessing differences in categorical variables between two groups. The contributions of the two group to NRS, ISI and SRI were tested through logistic regression analysis with the 3 variables (age, sex, Eichner's class) adjusted. Also, the interaction effect was tested using the logistic regression analysis in order to check whether the variables contributing to chewing discomfort have different patterns for each group. A confidence level of 95% and *P*-value of <0.05 were used to reveal significance differences. All statistical analyses were

Table 1 Demographic features and clinical characteristics of the two group.

Variable	Prosthetic (n = 193)	TMD (n = 199)	*P*-value
Age (y)	67.9 ± 8.2	62.5 ± 8.2	<0.001[a]
NRS	5.2 ± 3.2	4.3 ± 1.9	<0.001[a]
NRS grade			<0.001[b]
Non-severe (<7)	123 (63.7)	175 (87.9)	
Severe (≥7)	70 (36.3)	24 (12.1)	
Loss of post. tooth (n)			
Mx. premolar	1.5 ± 1.6	0.2 ± 0.8	<0.001[a]
Mx. molar	2.0 ± 1.6	0.6 ± 1.1	<0.001[a]
Mn. premolar	1.1 ± 1.5	0.2 ± 0.6	<0.001[a]
Mn. molar	2.0 ± 1.6	0.5 ± 1.1	<0.001[a]
Total	6.5 ± 5.2	1.5 ± 3.1	<0.001[a]
Gender (%)			<0.001[b]
Male	76 (39.4)	45 (22.6)	
Female	117 (60.6)	154 (77.4)	

[a], t-test.
[b], chi-square. NRS numeric rating scale, TMD temporomandibular disorder.

conducted with R software for Windows, version 4.0.5 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Comparison of demographic and clinical features

The clinical and descriptive data were compared between the TMD and prosthetic groups. As presented in Table 1, the average age of the TMD patients was significantly less than that of the prosthetic patients. There were significant differences between the two groups for NRS. The prosthetic group reported significantly higher NRS scores than the TMD group ($P < 0.001$). The incidence of severe chewing discomfort (NRS $\geq$7) was significantly higher in the prosthetic group (36.3%) than in the TMD group (12.1%). The prevalence of TMD was about three times higher in women (77.4%) than in men (22.6%). In the prosthetic group, there was a higher proportion in women (60.6%), about 1.5 times, than in men (39.4%) ($P < 0.001$).

Missing posterior teeth and occlusal condition

The prosthetic group lost a mean 6.5 ± 5.2 posterior teeth; this number was significantly higher than the 1.5 ± 3.1 teeth of the TMD group ($P < 0.001$) (Table 1). Table 2 shows the occlusal condition based on the Eichner's classification for the TMD and prosthetic groups. The distribution of Eichner's Classes A, B, and C among the TMD group was 85.9%, 12.1%, and 2.0%, respectively; for the prosthetic group the values were 31.6%, 47.2%, and 21.2%, respectively. Distribution of Eichner's Classification was significantly different between the two groups ($P < 0.001$).

Comparison of the ISI and SRI scores

The ISI and SRI scores of the two groups are presented in Table 3. The average of the ISI score was significantly higher in the TMD group than in the prosthetic group ($P < 0.001$). In the prosthetic group, 32.7% of patients reported mild to severe insomnia symptoms (ISI score $\geq$8) and clinically significant insomnia (ISI score $\geq$15) was observed in 9.9% of patients. The TMD group presented significantly higher prevalence (47.8% and 13.6%, respectively) than the prosthetic group ($P = 0.015$).

There was a significant difference in SRI score between the TMD and prosthetic groups. As shown in Table 3, the TMD group reported significantly higher scores than the prosthetic group in five subscales (tension, anger, depression, fatigue, and frustration) as well as in the total score.

Comparison of NRS, ISI, and SRI scores by sex for the two groups

In the TMD group, female patients reported significantly higher scores than male patients in four subscales (tension, somatization, fatigue, and frustration) as well as in the total score. However, there was no significant difference between genders regarding the prevalence of severe chewing discomfort and clinically significant insomnia. In the prosthetic group, female patients reported significantly higher prevalence of clinically significant insomnia than male patients (13.7% and 3.9%, respectively). Moreover,

Table 2 Comparison of occlusal condition according to Eichner's classification of the two group.

Eichner's classification (n, %)	Prosthetic (n = 193)	TMD (n = 199)	*P*-value
Class A	61 (31.6)	171 (85.9)	<0.001[a]
A1	23 (11.9)	113 (56.8)	
A2	22 (11.4)	47 (23.6)	
A3	16 (8.3)	11 (5.5)	
Class B	91 (47.2)	24 (12.1)	<0.001[a]
B1	31 (16.1)	10 (5.0)	
B2	24 (12.4)	5 (2.5)	
B3	19 (9.8)	5 (2.5)	
B4	17 (8.8)	4 (2.0)	
Class C	41 (21.2)	4 (2.0)	<0.001[a]
C1	5 (2.6)	0 (0.0)	
C2	22 (11.4)	3 (1.5)	
C3	14 (7.3)	1 (0.5)	

[a], chi-square. TMD temporomandibular disorder. A1, four support zones with no teeth lost; A2, four support zones with tooth loss on one side; A3, four support zones with tooth loss on both side; B1, three support zones; B2, two support zones; B3, only one support zones; B4, no support zones, occlusal contact at anterior teeth; C1, no support zones, teeth remaining on both arches; C2, one edentulous arch; C3, two edentulous arches.

Table 3 Comparison of SRI and ISI for the two group.

SRI	Prosthetic (n = 193)	TMD (n = 199)	*P*-value
T	2.8 ± 3.6	3.8 ± 4.0	0.001[a]
Ag	0.6 ± 1.4	0.9 ± 2.2	0.495[a]
S	1.5 ± 1.9	1.7 ± 2.1	0.141[a]
An	3.1 ± 3.7	3.8 ± 4.2	0.020[a]
D	4.2 ± 5.5	4.7 ± 5.7	0.035[a]
F	3.5 ± 3.2	4.3 ± 3.5	0.010[a]
Fr	3.5 ± 4.3	4.7 ± 5.4	0.020[a]
Total	19.3 ± 20.5	24.0 ± 24.1	0.004[a]
ISI score	5.9 ± 6.0	7.9 ± 5.9	0.001b[b]
ISI grade (n, %)			0.022[c]
0	130 (67.4)	104 (52.3)	
1	44 (22.8)	68 (34.2)	
2	14 (7.3)	21 (10.6)	
3	5 (2.6)	6 (3.0)	

[a], Mann–Whitney.
[b], t-test.
[c], Chi-square. ISI, insomnia severity index; SRI, stress response inventory; TMD, temporomandibular disorder; T, tension; Ag, aggression; S, somatization; An, anger; D, depression; F, fatigue; Fr, frustration. A total ISI score of 0–7 indicates grade '0', a total ISI score of 8–14 indicates grade '1', a total ISI score of 15–21 indicates grade '2', a total ISI score of 22–28 indicates grade '3'.

female patients presented significantly higher scores of frustration compared to male patients ($P = 0.044$). However, there was no significant difference between genders in the prevalence of severe chewing discomfort (Table 4).

Logistic regression

The odds ratio (OR) and 95% confidence interval for OR are shown in Table 5. Analysis of these data indicated that, in terms of severe chewing discomfort (NRS $\geq$7), the prosthetic group was more susceptible than the TMD group. However, in terms of clinically significant insomnia, patients in the TMD group were more susceptible than those in the prosthetic group. The interaction effect was tested using logistic regression analysis to check whether the subgroups of variables contributing to chewing discomfort have different patterns in the two groups. Fig. 1 shows the results of the logistic regression model with the subgroups of variables. It was found that the variable of sex had a statistically significant effect on severe chewing discomfort ($P = 0.041$). Analysis of these data indicated that female prosthetic patients were more susceptible to chewing discomfort than TMD patients.

Discussion

Changes in the coordination of masticatory structures, including the teeth, TMJ, and neuromuscular system, affect masticatory ability.[1,3] A positive association of number of functional teeth and presence of posterior occlusal support to chewing ability has been described. In 50-year-old subjects, Johansson et al.[25] identified a reduced number of teeth as the highest risk factor for impaired chewing ability. In a study by Zeng et al.[26] among Chinese people over 55 years of age, it was reported that chewing difficulties were highly associated with fewer teeth. J.P. Hatch et al.[27] found that number of functional tooth unit was confirmed as the key determinant of masticatory performance. Ikebe et al.[28] reported that occlusal support of the residual tooth was suggested to be the most important factor for determining the masticatory performance and dietary selection, which is closely related to quality of life. In this study, we found that the prosthetic group had significantly fewer remaining posterior teeth compared to the TMD group (Table 1). This is believed to be highly related to the difference in posterior tooth number and occlusal support (Table 2). Tooth loss reflects the ultimate outcome of oral diseases such as caries and periodontal disease, over one's life course. Because some contributing factors may accumulate throughout the life span, aging subsequently correlates with tooth loss.[6,7] We also found that the prosthetic group was older than the TMD group, which may be related to the significantly higher number of missing posterior teeth (Table 1). The prosthetic group reported significantly more severe chewing discomfort than the TMD group (Tables 1 and 5), suggesting that the reduction in occlusal support due to the loss of the posterior tooth contributes to chewing discomfort more than TMD pain. Based on the above, tooth loss was found to be associated with increasing age, and it can lead to severe chewing discomfort, which suggests that maintenance of natural teeth may be of primary importance for healthy mastication function.

In our study, we analyzed the psychological profile using the SRI and found that the TMD group scored significantly higher than the prosthetic group on five items (tension, anger, depression, fatigue, and frustration) as well as total score (Table 3). Many studies have shown that psychological factors, such as depression, anxiety, fatigue, and stress play an important role in the development and progression

Table 4 Gender differences in SRI, ISI and NRS in each two group.

	Prosthetic (n = 193)		*P*-value	TMD (n = 199)		*P*-value
Sex	M (n = 76)	F (n = 117)		M (n = 45)	F (n = 154)	
SRI						
T	2.9 ± 4.1	2.9 ± 3.3	0.592[a]	2.7 ± 3.0	4.1 ± 4.2	0.025[a]
Ag	0.7 ± 1.4	0.6 ± 1.4	0.371[a]	0.9 ± 1.9	0.9 ± 2.3	0.630[a]
S	1.5 ± 1.9	1.5 ± 2.0	0.933[a]	0.9 ± 1.1	2.0 ± 2.3	0.003[a]
An	2.7 ± 3.4	3.4 ± 3.8	0.172[a]	3.0 ± 3.4	4.1 ± 4.4	0.055[a]
D	4.1 ± 5.7	4.2 ± 5.4	0.756[a]	4.3 ± 5.4	4.9 ± 5.8	0.220[a]
F	3.6 ± 3.4	3.4 ± 3.1	0.958[a]	3.2 ± 2.4	4.6 ± 3.7	0.018[a]
Fr	3.0 ± 4.3	3.9 ± 4.2	0.044[a]	3.3 ± 4.2	5.0 ± 5.7	0.024[a]
Total	18.5 ± 21.6	20.0 ± 20.0	0.473[a]	18.2 ± 18.7	25.7 ± 25.3	0.022[a]
ISI score	4.8 ± 5.2	6.6 ± 6.3	0.091[b]	6.6 ± 4.9	8.3 ± 6.2	0.114[b]
Insomnia (n, %)			0.028[c]			0.805[c]
Non (<15)	73 (96.1)	101 (86.3)		40 (88.9)	132 (85.7)	
Insomnia (≥15)	3 (3.9)	16 (13.7)		5 (11.1)	22 (14.3)	
NRS (n, %)			0.094[c]			0.197[c]
Non-severe (<7)	54 (71.1)	69 (59.0)		37 (82.2)	138 (89.6)	
Severe (≥7)	22 (28.9)	48 (41.0)		8 (17.8)	16 (10.4)	

[a], Mann–Whitney.
[b], t-test.
[c], Chi-square. NRS numeric rating scale; ISI, insomnia severity index; SRI, stress response inventory; TMD, temporomandibular disorder; T, tension; Ag, aggression; S, somatization; An, anger; D, depression; F, fatigue; Fr, frustration.

Table 5 Logistic regression analysis of the two group according to severe chewing discomfort, insomnia.

	OR	95% CI	*P*-value
Severe chewing discomfort (NRS ≥7)			
Prosthetic	1.0 (ref.)		
TMD	0.241	0.144–0.404	0.001*
Insomnia (ISI ≥15)			
Prosthetic	1.0 (ref.)		
TMD	1.970	1.208–3.214	0.007*

* Statistically significant. CI, confidence interval; OR, odd ratio; NRS, numeric rating scale; TMD, temporomandibular disorder.

of TMD.[13–15,29] Conversely, TMD-related pain can itself induce psychological distress. The persistent pain associated with TMD severely limits the quality of life of TMD patients, and can affect their psychological status. Pain is the most common symptom of TMDs, which involve disturbances of mandibular movement, and functional impairment. As the pain becomes chronic, the importance of the central factor increases. Central factors include dysfunction of central pain inhibitory system, impairment of psychological health, and sleep deterioration. TMD patients show increased pain sensitivity, anxiety, depression, and stress due to its chronic nature.[30,31]

Insomnia, an abnormal and irregular sleep state, is one of the most common sleep disturbances among older adults and has long been associated with chronic pain and psychological factors. Wilson et al.[32] reported that patients with chronic pain with concurrent major depression and insomnia displayed serious pain-related psychosocial impairment. In a study by Dragioti et al.[33] that used the ISI to assess insomnia in older adults, they found that the group with chronic pain had a higher prevalence of clinical insomnia than those without pain or with acute pain. Several studies on TMD and sleep problems have found that sleep problems are common in TMD patients, especially in chronic TMD patients.[29,34,35] The results of this study showed that TMD patients reported pain as their primary symptom, and the TMD group had higher clinical insomnia and SRI scores than the prosthesis group (Tables 3 and 5).

We also investigated the gender effect on chewing difficulty, stress response, and insomnia. Our data showed

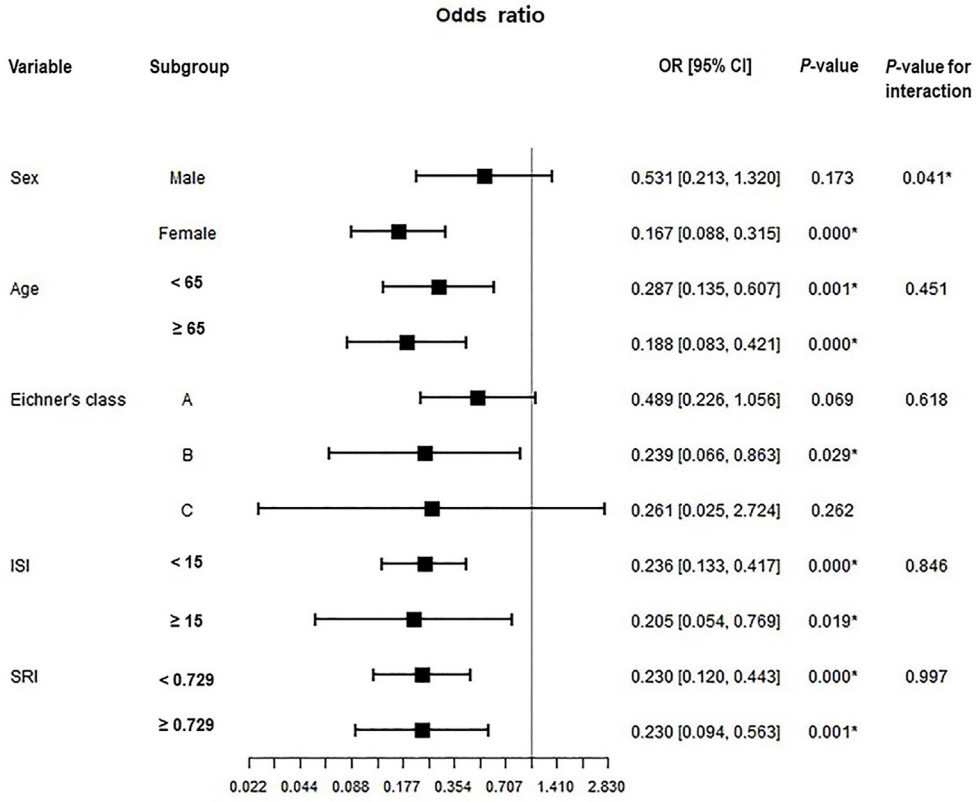

Figure 1 Logistic regression models of interaction effect in each subgroups on severe chewing discomfort. SRI scores were divided into two groups based on the 75th percentile. (Reference: prosthetic group). * Statistically significant. ISI, insomnia severity index; SRI, stress response inventory; CI, confidence interval; OR, odd ratio; A, occlusal contact in all the support zones; B, occlusal contact in few support zones; C, lack of occlusal contact in any support zones.

that women scored higher than men on four items (tension, somatization, fatigue, and frustration) as well as on the total score in SRI in the TMD group. In the prosthetic group, women also scored significantly higher than men on the frustration subscale of the SRI and had statistically significantly higher rates of clinical insomnia (Table 4). Several studies underline that gender plays an important role in human health, women have higher rates of chronic pain, insomnia, and psychological disorders, such as depression and anxiety compared to men.[36,37] Recently, individual differences in stress reactivity have been proposed as a potentially important risk factor for gender specific health problems in men and women, in addition to genetic, sociocultural, hormonal, and developmental factors.[38] TMD is known to be more prevalent in women, with reported 3:1 female to male diagnoses. The psychosocial factors that contain an enhanced response to stress stimuli, distress, anxiety, depression, or reduced coping strategies have been suggested to make gender differences in prevalence rates of TMD.[39,40] Our study found a statistically significant higher proportion of women in the TMD group (77.4% women, 22.6% men) than in the prosthetic group (60.6% women, 39.4% men), which may be related to the fact that the TMD group had a higher number of SRI subscales on which women scored higher than men compared to the prosthetic group (Tables 1 and 4). Furthermore, logistic regression models of interaction effect in subgroups showed that severe chewing discomfort is generally more susceptible in the prosthetic group than in the TMD group, and there is a particularly significant correlation with gender, especially for women (Fig. 1).

In this study, patients were selected from a single study site and the total number of patients was limited. Further studies are needed to infer causality across a wider range of patients, and economic, social, and other conditions. Furthermore, this study used only SRI as a psychological tool and ISI as sleep quality evaluation tool. More multifactorial analyses would be possible by using various psychological evaluation and sleep quality assessment tools.

Oral health and function are important in healthy ageing. One of the main goals of dental treatment is to maintain a lifelong healthy masticatory function. The findings of the present study suggested that maintaining a reasonable number of healthy natural teeth is the best guarantee for good masticatory ability with increasing age. Also, psychological stress and sleep quality should be routinely considered in TMD patients who present with chewing discomfort in order to improve outcomes, especially in women.

Declaration of competing interest

No potential conflicts of interest relevant to this article are reported.

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