



OPEN Impact of comorbid depression and anxiety on temporomandibular disorders related pain, sleep, function, behaviors, and quality of life

Adrian Ujin Yap^{1,2,3,8}, Yunhao Zheng^{1,4,8}, Tiqian Liu^{1,4,8}, Yijun Li^{1,4}, Po-Kam Wo^{1,4}, Shufang Du^{4,5,6}✉ & Xin Xiong^{1,4,7}✉

This study examined the prevalence of comorbid depression and anxiety in Chinese patients with temporomandibular disorders (TMDs), and their associations with pain intensity, sleep propensity, oral behaviors, jaw function, and oral health-related quality of life (OHRQoL). It also evaluated the likelihood of different TMD subtypes among individuals with no depression or anxiety (NC), depression alone (DA), anxiety alone (AA), and comorbid conditions (CC). Participants recruited from a dental hospital completed a survey comprising sociodemographics, the Diagnostic Criteria for TMDs (DC/TMD) Symptoms Questionnaire, Patient Health Questionnaire-9, Generalized Anxiety Disorder Scale-7, Numerical Pain Rating Scale, Epworth Sleepiness Scale, Oral Behaviors Checklist, Jaw Functional Limitation Scale-8, and the Oral Health Impact Profile for TMDs. Clinical examinations followed the DC/TMD protocol, classifying individuals into intra-articular (IT), pain-related (PT), or combined (CT) TMDs. Statistical analyses included chi-square tests, non-parametric methods, and multinomial logistic regression ($\alpha = 0.05$). Among 798 participants (mean age 29.8 years [SD 10.7]; 79.6% women), 48.0%, 10.8%, 7.9%, and 33.3% had NC, DA, AA, and CC, respectively. Significant differences were observed in pain intensity (CC/AA/DA > NC), sleep propensity (CC/DA > AA/NC), jaw overuse behavior (CC > AA/NC; DA > NC), jaw functional limitation (CC > DA > NC; AA > NC), and OHRQoL (CC > AA > DA > NC). Moderate correlations were observed between jaw functional limitation and OHRQoL across groups, with additional links to pain intensity in DA and AA ($r_s = 0.43$ – 0.54). In adjusted models, DA was associated with greater odds of CT (OR 2.26; 95% CI 1.19–4.27), and CC with higher odds of PT (OR 1.72; 95% CI 1.02–2.89) and CT (OR 1.78; 95% CI 1.14–2.77). Comorbid depression and anxiety were linked to increased pain, sleep propensity, oral behaviors, jaw dysfunction, and poorer OHRQoL, reinforcing the need for integrated psychological care.

Keywords Temporomandibular disorders, Depression, Anxiety, Pain, Sleep propensity, Oral behaviors, Jaw function, Oral health-related quality of life

Temporomandibular disorders (TMDs) are the second most common chronic musculoskeletal condition after low back pain, characterized by pain and/or dysfunction in the jaw joints, muscles, or supporting tissues^{1,2}. They constitute a significant public health concern, affecting as much as 34% of the global population, and

¹West China School of Stomatology, Sichuan University, Chengdu, China. ²Division of Dentistry, Ng Teng Fong General Hospital and Faculty of Dentistry, National University Health System, Singapore, Singapore. ³National Dental Research Institute Singapore, National Dental Centre Singapore and Duke-NUS Medical School, Singapore Health Services, Singapore, Singapore. ⁴State Key Laboratory of Oral Diseases, National Centre for Stomatology, and National Clinical Research Centre for Oral Diseases, West China Hospital of Stomatology, Sichuan University, Chengdu, China. ⁵Department of Nursing, West China Hospital of Stomatology, Sichuan University, Chengdu 610041, Sichuan, China. ⁶Department of Orthodontics, West China School of Stomatology, Sichuan University, Chengdu 610041, Sichuan, China. ⁷Department of Orthodontics and Department of Temporomandibular Joint, West China School of Stomatology, Sichuan University, Chengdu 610041, Sichuan, China. ⁸Adrian Ujin Yap and Yunhao Zheng contributed equally to this work. ✉email: dushufang@scu.edu.cn; drxiongxin@scu.edu.cn

often co-occur with other chronic pain conditions such as headaches, back pain, abdominal pain, fibromyalgia, myofascial pain, and irritable bowel syndrome^{2–4}. The prevalence of TMDs is higher in women, particularly those aged 20 to 40, compared to men^{5,6}. As indicated by the contemporary Diagnostic Criteria for TMDs (DC/TMD) and its structured reporting framework, these disorders can be classified into three categories: intra-articular TMDs (IT), pain-related TMDs (PT), and combined TMDs (CT)^{7,8}. TMDs have been shown to impair both health (HRQoL) and oral health-related quality of life (OHRQoL), the latter referring to the impact of oral health conditions on an individual's overall well-being and daily functioning^{9–11}. Conversely, therapeutic interventions for TMDs were found to enhance OHRQoL¹². The complex etiology of TMDs aligns with the biopsychosocial model of illness and involves various factors, such as age, gender, reproductive hormones, trauma, oral parafunction, somatic symptoms, sleep disorders, perceived stress, as well as depression and anxiety^{13–15}.

Mental health problems are the leading cause of global health burden, with depression occurring in 4.4% of people and anxiety in 3.6%, making them the primary contributors^{16,17}. Due to the Coronavirus Disease 2019 (COVID-19) pandemic, the prevalence of depression and anxiety has risen by approximately 28% and 26%, respectively¹⁸. Depression and anxiety are distinct negative emotional states, each defined by unique symptoms and impact. Depression is characterized by persistent sadness, loss of interest, and feelings of hopelessness, while anxiety involves excessive worry, fear, and heightened autonomic arousal¹⁹. The two emotional states often coexist and have been closely linked to HRQoL, with their comorbidity leading to increased impairment^{20–22}. Possible reasons for their comorbidity include the inadequate discriminative ability of measurement tools, exposure to stressful life events, shared negative effects like insufficient and disrupted sleep, as well as common underlying genetic and biological vulnerabilities^{23,24}.

Depression and anxiety are frequently observed in individuals with musculoskeletal conditions involving the lower back, hip, or knee²⁵. TMDs have also been associated with elevated levels of depression and anxiety in both patient and general populations^{26–28}. Moreover, TMD patients with jaw muscle pain tend to experience higher levels of depression and anxiety compared to those with other TMD subtypes²⁹. The estimated prevalence of depression and anxiety among East Asian TMD patients is approximately 38% and 34%, respectively, with moderate-to-strong correlations between the two emotional states across different TMD subtypes³⁰. This suggests that many TMD patients do not experience psychological distress, while those who do may exhibit anxious depression. Comorbid depression and anxiety can amplify psychological distress and heighten perceptions of orofacial pain, jaw disability, and impairments in OHRQoL. However, the nuanced effects of anxious depression on these and other TMD-related outcomes have not been thoroughly investigated. Differentiating TMD patients with such comorbidity is crucial, as it may influence treatment strategies and prognosis³¹. By identifying and addressing the impact of comorbid depression and anxiety, clinicians can provide more precise and personalized care.

With the aforementioned premise, the objectives of this study were to establish the prevalence of comorbid depression and anxiety in Chinese TMD patients and to examine the associations of depression and anxiety, both alone and concurrently, with orofacial pain intensity, sleep propensity, oral behaviors, jaw function, and OHRQoL. Additionally, the odds of different TMD subtypes were determined in patients with no depression or anxiety, depression alone, anxiety alone, and comorbid depression and anxiety. The research hypotheses were: (a) The majority of TMD patients with psychological distress exhibit anxious depression, (b) Comorbidity between depression and anxiety is associated with significantly higher levels of pain intensity, daytime sleepiness, jaw overuse behavior, and jaw functional limitation, as well as poorer OHRQoL. (c) Correlations among pain intensity, sleep propensity, oral behaviors, jaw function, and OHRQoL differ based on psychological subgroups, and (d) Comorbid depression and anxiety are linked to higher odds of painful TMDs.

Material and methods

Study sample and TMD subtypes

This observational study was granted ethics approval by the Institutional Review Board at the West China Hospital of Stomatology, Sichuan University (Reference: WCHSIRB-D-2022-212) and followed the Helsinki Declaration for the ethical principles for medical research involving human subjects. To achieve 95% power with an alpha error of 0.05, a minimum of 436 participants was necessary across four comparison groups. This estimate was generated using G*Power software Version 3.1.9.3 with an Analysis of Variance model, assuming a small effect size of 0.20³². Participants were enrolled from a consecutive series of first-time adult patients seeking TMD treatment at the West China Hospital of Stomatology between January 2022 and May 2024. The inclusion criteria required participants to be ≥ 18 years old, of Chinese ethnicity, literate in Chinese, diagnosed with TMDs, and to have complete DC/TMD data and assessments. Exclusion criteria included a history of TMJ trauma or surgery, analgesic and neuroactive medication use in the prior three months, and the presence of other orofacial pain conditions, debilitating psychiatric disorders, systemic diseases, or cognitive deficits. All eligible individuals received the study details, and informed consent was obtained for their participation. Participants were instructed to complete a comprehensive survey in Chinese, covering socio-demographic attributes and the following assessments: DC/TMD Symptoms Questionnaire (SQ), Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder Scale-7 (GAD-7), Numerical Pain Rating Scale (NPRS), Epworth Sleepiness Scale (ESS), Oral Behaviors Checklist (OBC), Jaw Functional Limitation Scale-8 (JFLS-8), and Oral Health Impact Profile for TMDs (OHIP-TMD)^{7,34–40}. They were then examined by three specialists trained and experienced in the DC/TMD methodology. The examination evaluated pain locations, pain during palpation or movement, jaw movements and deviations, and TMJ sounds. Cone-beam computed tomography and/or magnetic resonance imaging were performed to verify the presence of advanced or neoplastic intra-articular conditions. TMD diagnoses were made based on reported symptoms, clinical signs, supplementary diagnostic imaging, and the DC/TMD algorithms. Participants were subsequently classified into IT (comprising TMJ disc displacements,

degenerative joint disease, and subluxation), PT (comprising TMJ arthralgia, masticatory myalgia, and headaches attributed to TMDs), and CT subtypes.

Study measures

Depression and anxiety

Depression and anxiety were evaluated using the PHQ-9 and GAD-7, which consist of nine and seven items, respectively^{34,35}. The psychometric properties and operating characteristics of both measures for identifying depressive and anxiety disorders are well-documented⁴¹. Items are scored on a 4-point response scale that ranges from "not at all" (0 points) to "nearly every day" (3 points). Total scores were computed and categorized as follows: for depression—mild (≥ 5 points), moderate (≥ 10 points), moderately severe (≥ 15 points), and severe (≥ 20 points); for anxiety—mild (≥ 5 points), moderate (≥ 10 points), and severe (≥ 15 points). Participants were considered to have depression or anxiety alone if they scored ≥ 5 points in either condition and were classified as having comorbid depression and anxiety (anxious depression) if they scored ≥ 5 points in both.

Pain intensity and sleep propensity

The NPRS was derived from the pain intensity component of the Graded Chronic Pain Scale (GCPS)³⁶. Current pain intensity was assessed on a 0–10 numerical scale, with 0 representing "no pain" and 10 indicating "the worst pain imaginable". Sleep propensity resulting from inadequate or poor-quality sleep was evaluated using the ESS, which measures the tendency to fall asleep or doze off during eight different activities.³⁷ Items are scored on a 4-point Likert scale, ranging from "would never nod off" (0 points) to "high chance of nodding off" (3 points). Total ESS scores > 10 signify excessive daytime sleepiness (EDS)^{37,42}.

Oral behaviors

Oral behaviors were assessed with the OBC, which comprised two sleeping-state (SA) and nineteen waking-state (WA) oral activities³⁸. Items were scored on a 5-point Likert scale, that ranged from "none of the time" (0 points) to "4–7 nights per week" or "all of the time" (4 points). Total OBC scores, reflecting "jaw overuse behavior", were categorized as follows: normal (0–16 points), low (17–24 points), and high (25–84 points)⁴². SA and WA subscale scores were calculated by summing their respective items.

Jaw functional limitation

Jaw functional limitation was evaluated using the JFLS-8, which measures the ability to perform eight functional activities related to the jaws, such as chewing, speaking, and yawning. Items are rated on a 0–10 numerical scale, extending from "no" to "extreme limitation". Total JFLS-8 scores were computed, with higher scores signifying increased jaw function disability and impairment^{30,38}.

OHRQoL

OHRQoL was assessed using the OHIP-TMD, a condition-specific measure consisting of 22 items across seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.^{40,44} Items are scored on a 5-point Likert scale, that ranged from "never" (0 points) to "very often" (4 points). Total and domain OHIP scores were calculated by summing the scores of all 22 items and the corresponding items within each domain. Higher OHIP scores signify poorer or diminished OHRQoL^{40,44}.

Statistical analyses

Statistical analyses were performed using R software (version 4.2.2, R Foundation for Statistical Computing, Vienna, Austria), with a significance threshold set at $p < 0.05$. Qualitative data were summarized as frequencies and percentages and analyzed using the Chi-square test with Benjamini–Hochberg correction. Quantitative data were described as means with standard deviations (SDs) and medians with interquartile ranges (IQRs). The Shapiro–Wilk test was applied to assess normality, which indicated a non-normal distribution. Consequently, non-parametric tests, including the Kruskal–Wallis test, post-hoc Dunn test, and Spearman's rank-order correlation with Benjamini–Hochberg correction, were utilized for analysis. Correlation coefficients (r) between variables, grouped according to psychological status, were categorized as follows: weak (≥ 0.1), moderate (≥ 0.4), strong (≥ 0.7), or very strong (≥ 0.9)⁴⁵. The odds of the different TMD subtypes were determined with multinomial logistic regression analysis using the following three models: Model 1 – adjusted for sex, age, and education; Model 2 – adjusted for sociodemographics and pain intensity; and Model 3 – adjusted for socio-demographics, pain intensity, sleep propensity, and oral behaviors.

Results

Of the 859 patients who met the inclusion criteria, none declined participation. However, 37 were excluded due to prior TMJ trauma or surgery and 24 due to recent analgesic use. The final sample comprised 798 participants aged between 18 and 75 years, with a mean age of 29.8 years (SD = 10.7). Women accounted for 79.6% of the participants, and 71.1% had attained secondary education. Among the 798 participants, 48.0% (383) had no depression or anxiety (NC), while 10.8% (86), 7.9% (63), and 33.3% (266) experienced depression alone (DA), anxiety alone (AA), and comorbid conditions (CC), respectively. Though there were no significant age differences, the CC group had a significantly higher proportion of women compared to the NC group. The CC group also exhibited significantly greater depression and anxiety scores than the other groups. However, the severity of depression and anxiety in the DA, AA, and CC groups was mostly mild, ranging from 60.5 (161/266)

to 95.2% (60/63). Notable variations were observed in the distribution of TMD subtypes among the four groups, with the CC group presenting the highest proportion of CT at 50.0% (133/266) (Table 1).

Tables 2 and 3 reflect the mean/median NPRS, ESS, OBC, JFLS-8, and OHIP-TMD scores for the four study groups. Significant differences in pain intensity (CC, AA, DA > NC), sleep propensity (CC, DA > AA, NC), jaw overuse behavior (CC > AA, NC; DA > NC), jaw functional limitation (CC > DA > NC; AA > NC), and OHRQoL (CC > AA > DA > NC) were identified. Additionally, significant differences were observed in all OHIP domains, with the CC group generally showing the highest scores across all domains (Table 3).

Tables 4 and 5 present the results of the correlation and multinomial regression analyses. For all study groups, moderate correlations were found between jaw functional limitation and OHRQoL ($r_s = 0.44\text{--}0.54$). Furthermore, pain intensity was moderately correlated with both jaw functional limitation and OHRQoL for the DA group ($r_s = 0.44/0.43$), whereas it was moderately associated with OHRQoL for the AA group ($r_s = 0.50$).

In the non-adjusted regression analysis, DA was linked to higher odds of CT (OR = 2.17; 95% CI = 1.26–3.73), while CC was associated with increased odds of both PT (OR = 2.46; 95% CI = 1.59–3.80) and CT (OR = 2.64; 95% CI = 1.82–3.83), using the NC and IT groups as reference categories. These associations persisted even after adjustments for socio-demographics (Model 1), pain intensity (Model 2), as well as sleep propensity and oral behaviors (Model 3). In Model 3, DA remained linked to increased odds of CT (OR = 2.26; 95% CI = 1.19–4.27), and CC continued to be associated with higher odds of both PT (OR = 1.72; 95% CI = 1.02–2.89) and CT (OR = 1.78; 95% CI = 1.14–2.77), with NC and IT groups as benchmarks.

Discussion

This study examined the prevalence and relationships of comorbid depression and anxiety with pain intensity, sleep propensity, oral behaviors, jaw function, and OHRQoL, and determined the odds of different TMD subtypes

Variables	All patients	No depression or anxiety (NC)	Depression alone (DA)	Anxiety alone (AA)	Comorbid depression and anxiety (CC)	P-value Post-hoc
Total, n (%)	798 (100)	383 (47.99)	86 (10.78)	63 (7.89)	266 (33.33)	
Depression (PHQ-9)						
Mean (SD)	4.80 (4.57)	1.44 (1.39)	7.16 (3.05)	2.44 (1.41)	9.44 (3.95)	<0.001 CC > DA > AA > NC
Median (IQR)	4.00 (6.00)	1.00 (2.50)	6.00 (3.00)	3.00 (3.00)	9.00 (5.00)	
Depression severity						
Normal, n (%)	446 (55.89)	383 (100.00)	0 (0.00)	63 (100.00)	0 (0.00)	
Mild, n (%)	235 (29.45)	0 (0.00)	74 (86.05)	0 (0.00)	161 (60.53)	<0.001
Moderate, n (%)	76 (9.52)	0 (0.00)	8 (9.30)	0 (0.00)	68 (25.56)	
Moderately severe, n (%)	35 (4.39)	0 (0.00)	3 (3.49)	0 (0.00)	32 (12.03)	
Severe, n (%)	6 (0.75)	0 (0.00)	1 (1.16)	0 (0.00)	5 (1.88)	
Anxiety (GAD-7)						
Mean (SD)	4.54 (4.56)	1.29 (1.39)	2.53 (1.31)	6.48 (1.72)	9.41 (4.16)	<0.001 CC > AA > DA > NC
Median (IQR)	3.00 (6.00)	1.00 (2.00)	3.00 (2.00)	6.00 (2.00)	8.00 (6.00)	
Anxiety severity						
Normal, n (%)	469 (58.77)	383 (100.00)	86 (100.00)	0 (0.00)	0 (0.00)	
Mild, n (%)	223 (27.94)	0 (0.00)	0 (0.00)	60 (95.24)	163 (61.28)	<0.001
Moderate, n (%)	77 (9.65)	0 (0.00)	0 (0.00)	2 (3.17)	75 (28.20)	
Severe, n (%)	29 (3.63)	0 (0.00)	0 (0.00)	1 (1.59)	28 (10.53)	
Sex						
Male, n (%)	163 (20.43)	94 (24.54)	20 (23.26)	8 (12.70)	41 (15.41)	0.013
Female, n (%)	635 (79.57)	289 (75.46)	66 (76.74)	55 (87.30)	225 (84.59)	
Age						
Mean (SD)	29.81 (10.67)					0.507
Median (IQR)	26.00 (11.00)	27.00 (12.00)	27.00 (7.00)	27.00 (11.00)	26.00 (10.75)	
Education						0.277
Primary, n (%)	132 (16.54)	55 (14.36)	11 (12.79)	11 (17.46)	55 (20.68)	
Secondary, n (%)	567 (71.05)	280 (73.11)	63 (73.26)	44 (69.84)	180 (67.67)	
Higher, n (%)	99 (12.41)	48 (12.53)	12 (13.95)	8 (12.70)	31 (11.65)	
TMD subtypes						
Intra-articular n (%)	288 (36.09)	174 (45.43)	25 (29.07)	24 (38.10)	65 (24.44)	<0.001
Pain-related, n (%)	175 (21.93)	74 (19.32)	19 (22.09)	14 (22.22)	68 (25.56)	
Combined n (%)	335 (41.98)	135 (35.25)	42 (48.84)	25 (39.68)	133 (50.00)	

Table 1. Socio-demographic and psychological characteristics of the four patient groups. SD: standard deviation; IQR: Interquartile range. Results of Chi-square test and Kruskal–Wallis/post-hoc Dunn's test with Benjamini–Hochberg adjustment. Bold indicates $p < 0.05$.

Variables	All patients	No depression or anxiety (NC)	Depression alone (DA)	Anxiety alone (AA)	Comorbid depression and anxiety (CC)	P-value Post-hoc
	798 (100)	383 (47.99)	86 (10.78)	63 (7.89)	266 (33.33)	
<i>Pain intensity</i>						
Current pain						
Mean (SD)	1.69 (1.89)	1.29 (1.69)	1.73 (1.77)	1.83 (1.75)	2.22 (2.10)	<0.001 CC,AA,DA > NC
Median (IQR)	1.00 (3.00)	0.00 (2.00)	2.00 (3.00)	2.00 (3.00)	2.00 (3.00)	
Sleep propensity (ESS)						
Mean (SD)	6.47 (3.46)	5.91 (3.21)	7.23 (3.14)	5.51 (3.29)	7.24 (3.74)	<0.001 CC,DA > AA,NC
Median (IQR)	6.00 (5.00)	6.00 (4.00)	7.00 (4.00)	5.00 (5.00)	7.00 (4.00)	
Oral behaviors (OBC)						
Jaw overuse behavior						
Mean (SD)	24.57 (9.08)	22.50 (9.00)	25.85 (8.41)	24.00 (8.09)	27.28 (8.88)	<0.001 CC > AA,NC DA > NC
Median (IQR)	25.00 (13.00)	23.00 (12.00)	25.00 (9.00)	24.00 (12.50)	27.50 (12.00)	
Sleeping-state oral activity (SA)						
Mean (SD)	4.26 (2.14)	4.03 (2.12)	4.36 (2.06)	4.25 (2.03)	4.57 (2.18)	0.016 CC > NC
Median (IQR)	4.00 (3.00)	4.00 (2.50)	4.00 (3.00)	4.00 (3.00)	4.00 (3.00)	
Waking-state oral activity (WA)						
Mean (SD)	20.31 (7.97)	18.47 (7.81)	21.49 (7.55)	19.75 (7.08)	22.71 (7.87)	<0.001 CC > AA,NC DA > NC
Median (IQR)	20.00 (11.00)	18.00 (10.00)	21.00 (7.75)	20.00 (10.50)	23.00 (11.00)	
Jaw function (JFLS-8)						
Mean (SD)	14.60 (11.46)	11.24 (9.68)	14.01 (10.35)	17.06 (10.68)	19.05 (12.69)	<0.001 CC > DA > NC AA > NC
Median (IQR)	13.00 (15.00)	10.00 (13.50)	13.00 (13.00)	16.00 (10.50)	17.00 (15.75)	

Table 2. Mean/median pain intensity, sleep propensity, oral behavior, and jaw functional limitation scores for the four study groups. SD: standard deviation; IQR: Interquartile range; ESS: Epworth Sleepiness Scale; OBC: Oral Behaviors Checklist; JFLS-8: Jaw Functional Limitation Scale-8. Results of Chi-square test and Kruskal–Wallis/post-hoc Dunn’s test with Benjamini–Hochberg adjustment. Bold indicates $p < 0.05$.

based on psychological subgroups. The first and second research hypotheses were confirmed, with close to two-thirds of psychologically distressed participants having comorbid depression and anxiety, and this subgroup showing significantly higher pain intensity, daytime sleepiness, jaw overuse behavior, jaw functional limitation, and lower OHRQoL. Additionally, as correlations among pain intensity, jaw functional limitation, and OHRQoL varied across psychological subgroups, and comorbid depression and anxiety were linked to painful TMDs, the third and fourth hypotheses were also supported. Apart from the ESS and OHIP-TMD, all other measures used in this study, including the PHQ-9 and GAD-7, are part of Axis II (psychosocial and behavioral aspects) of the evidence-based and internationally recognized DC/TMD⁷. While the ESS screens for EDS, which has been associated with sleep-disordered breathing and PT, the OHIP-TMD is the only OHRQoL instrument specifically designed for TMDs^{42,46}. Tailored to capture TMD symptoms and their impacts, the OHIP-TMD offers improved sensitivity, specificity, responsiveness, and reduced “floor effects” compared to generic OHRQoL measures^{11,47}.

Prevalence of psychological subgroups

Approximately half of the participants had no depression or anxiety, reinforcing initial findings from Korean patients, which indicated that many individuals with TMDs do not suffer from psychological distress³⁰. If assessed independently, 44.1% and 41.3% of participants experienced depressive and anxiety symptoms, respectively, aligning with prevalence rates reported in past studies utilizing various psychometric tests^{26,27}. However, when comorbid conditions were considered, 33.3% of the participants had anxious depression, whereas only 18.7% had either depression or anxiety alone. Consequently, approximately two-thirds (64.1%; 266/415) of the psychologically distressed individuals exhibited comorbid depression and anxiety, corroborating the 63–67% range found in a large longitudinal cohort study⁴⁸. Therefore, identifying comorbid depression and anxiety is essential for accurately determining the extent of psychological distress in TMD research, a practice that is not widely performed. In addition to the possible reasons offered earlier, this comorbidity may also result from neurochemical imbalances involving serotonin, norepinephrine, and gamma-aminobutyric acid (GABA), which are vital for mood regulation and stress response. Moreover, emerging evidence suggest that depression and anxiety share hypofunction in the prefrontal cortex and hyperactivation in the amygdala during emotional processing, explaining their frequent co-existence and overlapping symptoms^{49,50}.

Subgroup comparison analysis

Significant differences among the psychological subgroups were revealed, with comorbid depression and anxiety consistently presenting the worst outcomes for all variables. Individuals with comorbid conditions had significantly greater discomfort than the NC subgroup, more daytime sleepiness, and higher jaw overuse behavior compared to both the AA and NC subgroups. Moreover, they experienced greater jaw disability than the DA and

Variables	All patients	No depression or anxiety (NC)	Depression alone (DA)	Anxiety alone (AA)	Comorbid depression and anxiety (CC)	P-value Post-hoc
OHRQoL (total OHIP)						<0.001 CC > AA > DA > NC
Mean (SD)	31.93 (16.73)	23.56 (13.04)	28.51 (13.79)	37.30 (12.51)	43.83 (15.63)	
Median (IQR)	32.00 (23.00)	23.00 (18.00)	30.00 (21.75)	37.00 (17.50)	43.50 (20.00)	
Functional limitation						<0.001 CC, AA > DA, NC
Mean (SD)	3.68 (2.10)	3.24 (2.08)	3.59 (2.01)	4.24 (2.03)	4.22 (2.02)	
Median (IQR)	4.00 (3.00)	3.00 (2.50)	4.00 (3.00)	5.00 (2.00)	4.00 (3.00)	
Physical pain						<0.001 CC > AA, DA > NC
Mean (SD)	6.53 (3.98)	5.12 (3.51)	6.36 (3.85)	6.73 (3.64)	8.56 (3.87)	
Median (IQR)	6.00 (5.00)	5.00 (5.00)	6.50 (6.75)	7.00 (5.00)	8.00 (5.00)	
Psychological discomfort						<0.001 CC, AA > DA, NC
Mean (SD)	8.05 (4.15)	6.24 (3.63)	6.97 (3.55)	9.89 (3.20)	10.58 (3.76)	
Median (IQR)	8.00 (6.00)	6.00 (6.00)	7.00 (4.00)	10.00 (4.00)	11.00 (5.00)	
Physical disability						<0.001 CC, AA > DA, NC
Mean (SD)	3.06 (1.94)	2.51 (1.78)	2.73 (1.98)	3.41 (1.62)	3.88 (1.94)	
Median (IQR)	3.00 (2.00)	3.00 (3.00)	3.00 (2.00)	3.00 (2.00)	4.00 (2.00)	
Psychological disability						<0.001 CC > AA > DA > NC
Mean (SD)	6.71 (4.64)	4.27 (3.53)	5.58 (3.45)	8.46 (3.33)	10.18 (4.32)	
Median (IQR)	7.00 (7.00)	4.00 (6.00)	6.00 (5.75)	8.00 (5.00)	10.00 (6.00)	
Social disability						<0.001 CC > AA > DA > NC
Mean (SD)	1.63 (1.66)	0.85 (1.09)	1.23 (1.19)	1.79 (1.23)	2.86 (1.81)	
Median (IQR)	1.00 (3.00)	0.00 (2.00)	1.00 (2.00)	2.00 (2.00)	3.00 (2.00)	
Handicap						<0.001 CC > AA > DA > NC
Mean (SD)	2.27 (1.94)	1.33 (1.40)	2.05 (1.64)	2.78 (1.67)	3.57 (1.98)	
Median (IQR)	2.00 (4.00)	1.00 (2.00)	2.00 (3.00)	3.00 (2.00)	4.00 (3.00)	

Table 3. Mean/median total and domain OHIP-TMD scores for the four study groups. SD: standard deviation; IQR: Interquartile range; OBC: Oral Behaviors Checklist. Results of Kruskal–Wallis/post-hoc Dunn’s test with Benjamini–Hochberg adjustment. Bold indicates $p < 0.05$.

NC subgroups and poorer OHRQoL than all other subgroups. Of interest, the CC subgroup exhibited high jaw overuse behaviors and significantly increased waking-state oral activities compared to all subgroups except DA. They also had significantly greater OHIP domain scores than all subgroups except AA, specifically in functional limitation, psychological discomfort, and physical disability domains. Individuals with depression alone showed significantly increased discomfort, jaw overuse behavior, jaw disability, and poorer OHRQoL than the NC subgroup, as well as more daytime sleepiness than both the AA and NC subgroups. Additionally, those with anxiety alone experienced significantly greater discomfort and jaw disability than the NC subgroup, alongside poorer OHRQoL than both the DA and vgyy.

Findings demonstrate that depression and anxiety, especially when comorbid, impact orofacial pain, sleep propensity, oral behaviors, jaw function, and OHRQoL in TMD patients. Addressing these mental health issues can potentially reduce related symptoms and dysfunction, thereby enhancing both physical and mental well-being. Therefore, TMD patients should undergo routine psychological screening, and an interprofessional, multimodal approach involving dentists, physiotherapists, sleep physicians, and mental health specialists should be implemented for those with significant psychosocial distress. In addition to conventional noninvasive management strategies like pharmacological, physical, and oral appliance therapy, positive psychological interventions (PPIs) such as cognitive-behavioral and mindfulness-based therapies may also help mitigate the negative physical and psychosocial consequences of TMDs. PPIs promote positive thinking, feelings, behaviors, and resilience, and have been found to reduce physical/psychological symptoms and suffering while improving overall quality of life^{51,52}.

Correlation and regression analyses

For all psychological subgroups, jaw functional limitation was moderately correlated with OHRQoL. Moreover, pain intensity, which is related to jaw function, showed near-moderate or moderate correlations with OHRQoL for the CC, DA, and AA groups, confirming the role of pain in OHRQoL⁵³. These relationships were reported in other East Asian patient samples, and TMD interventions that reduce pain and enhance function can improve OHRQoL, although their effectiveness in reducing depression and anxiety may be modest^{12,53,54}. In the non-adjusted regression analysis, the DA subgroup was associated with a 2.2 times higher likelihood of having CT. The CC subgroup had approximately 2.5 times the likelihood of experiencing PT as well as CT. These associations persisted even after adjusting for socio-demographics and other variables, with the DA subgroup showing a 2.3 times likelihood of CT, and the CC subgroup having a 1.7 times likelihood of PT and CT. Findings indicate that

Groups	Variables	PI	SP	OB	JF	QL
No depression or anxiety (NC)	PI	1***	0.08	−0.04	0.38***	0.36***
	SP	0.08	1***	0.37***	0.11*	0.24***
	OB	−0.04	0.37***	1***	0.08	0.25***
	JF	0.38***	0.11*	0.08	1***	0.54***
	QL	0.36***	0.24***	0.25***	0.54***	1***
Depression alone (DA)	PI	1***	0.09	0.15	0.44***	0.43***
	SP	0.09	1***	0.33**	0.07	0.09
	OB	0.15	0.33**	1***	0.09	0.16
	JF	0.44***	0.07	0.09	1***	0.50***
	QL	0.43***	0.09	0.16	0.50***	1***
Anxiety alone (AA)	PI	1***	−0.03	−0.23	0.34*	0.50***
	SP	−0.03	1***	0.31*	0.01	−0.13
	OB	−0.23	0.31*	1***	−0.04	0.01
	JF	0.34**	0.01	−0.04	1***	0.44**
	QL	0.50***	−0.13	0.01	0.44***	1***
Comorbid depression and anxiety (CC)	PI	1***	−0.07	0.11	0.33***	0.39***
	SP	−0.07	1***	0.23***	0.05	−0.02
	OB	0.11	0.23***	1***	0.17*	0.18**
	JF	0.33***	0.05	0.17**	1***	0.53***
	QL	0.39***	−0.02	0.18**	0.53***	1***

Table 4. Correlations among the different biopsychococial and behavioral factors. PI: Pain intensity; SP: Sleep propensity (ESS); JF: Jaw functional limitation (JFLS-8); QL: Oral health-related quality of life (OHIP-TMD). Results of Spearman’s correlation with Benjamini–Hochberg Adjustment. *indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$, and bold indicates correlation coefficient ≥ 0.4

depression, whether alone or coupled with anxiety, significantly increases the risk of painful TMDs (PT and/or CT).

While painful TMDs have been associated with increased levels of depression and anxiety, the exact underlying mechanisms remain unclear²⁹. Recent research suggests these associations are more closely related to somatization than to orofacial pain characteristics in TMD patients⁵⁵. Somatization, the expression of psychological distress through physical symptoms is common in East Asian cultures partly due to societal stigma surrounding mental illness⁵⁵. It is a key feature of somatic symptom disorder and can mediate the relationship between pain and depression as well as anxiety⁵⁶. The biological processes linking somatization to depression and anxiety are not fully understood. However, factors such as metabolic, immune-inflammatory, autonomic, and hypothalamic–pituitary–adrenal dysregulation, as well as structural/functional brain alterations and neurotransmitter imbalances, have been implicated^{57,58}. Cognitive processes linked to somatization, such as heightened sensitivity to physical symptoms and catastrophizing, can exacerbate depression and anxiety and explain the co-existence of other chronic pain conditions in TMDs^{4,59}.

Study strengths and limitations

This pioneering study is the first to delve into the marked impact of comorbid depression and anxiety on orofacial pain, sleep propensity, oral behaviors, jaw function, and OHRQoL in TMD patients, providing new insights into their interconnections among different psychological subgroups. Apart from its novelty, the study’s strengths include the use of evidence-based DC/TMD and its validated measures, a large sample size, and multivariate analysis, which allows for a nuanced understanding of how different psychological subgroups relate to TMD subtypes. Moreover, by investigating multiple outcomes, the study provides a holistic perspective on how comorbid depression and anxiety affect TMD patients, which has implications for clinical practice.

While the study had its strengths, it also encountered several limitations. First, the cross-sectional design does not permit the establishment of causality between depression, anxiety, and TMD-related outcomes. Furthermore, without longitudinal data, the long-term effects of comorbid depression and anxiety cannot be determined, including changes in oral behaviors, jaw function, and OHRQoL. Second, as the study focused on Chinese TMD patients from a single site, the findings may not be generalizable to other racial groups or the broader population. Third, the predominance of female participants, which corresponds with the higher prevalence of TMDs in women, could potentially introduce a gender bias in the results^{5,6}. Additionally, the study is subject to information biases such as recall and social desirability effects, due to its reliance on self-reported psychological and physical symptoms, impacts, and behaviors⁶⁰. Lastly, unexamined confounders, including other psychosocial factors such as somatization, catastrophization, and personality traits, as well as lifestyle behaviors, may have influenced the results. However, practical constraints and the need to prevent survey fatigue limited the number of measures that could be included. Prospective studies should aim for a more diverse sample, including participants from different racial groups and settings, employ a longitudinal design, and explore unexamined confounders.

	IT	PT		CT	
Variables	Odds ratio (95% CI)	Odds ratio (95% CI)	P-value	Odds ratio (95% CI)	P-value
Non adjusted					
NC	Reference	Reference	–	Reference	–
DA	Reference	1.79 (0.93–3.44)	0.083	2.17 (1.26–3.73)	0.005
AA	Reference	1.37 (0.67–2.80)	0.385	1.34 (0.73–2.46)	0.339
CC	Reference	2.46 (1.59–3.80)	<0.001	2.64 (1.82–3.83)	<0.001
Adjusted model 1					
NC	Reference	Reference	–	Reference	–
DA	Reference	1.92 (0.99–3.73)	0.053	2.25 (1.30–3.89)	0.004
AA	Reference	1.36 (0.66–2.80)	0.409	1.23 (0.67–2.26)	0.507
CC	Reference	2.62 (1.68–4.08)	<0.001	2.55 (1.75–3.72)	<0.001
Adjusted model 2					
NC	Reference	Reference	–	Reference	–
DA	Reference	1.93 (0.91–4.09)	0.086	2.26 (1.20–4.27)	0.012
AA	Reference	1.07 (0.46–2.44)	0.882	1.00 (0.49–2.02)	0.992
CC	Reference	1.78 (1.07–2.95)	0.025	1.82 (1.18–2.78)	0.007
Adjusted model 3					
NC	Reference	Reference	–	Reference	–
DA	Reference	1.90 (0.89–4.05)	0.095	2.26 (1.19–4.27)	0.013
AA	Reference	1.01 (0.44–2.34)	0.979	0.97 (0.48–1.97)	0.926
CC	Reference	1.72 (1.02–2.89)	0.041	1.78 (1.14–2.77)	0.011

Table 5. Psychological factors associated with the three TMD subtypes. NC: No depression or anxiety; DA: Depression alone; AA: Anxiety alone; CC: Comorbid depression and anxiety. Model 1: adjusted for sex, age, and education. Model 2: adjusted for socio-demographics and pain intensity. Model 3: adjusted for socio-demographics, pain intensity, sleep propensity, and oral behaviors. Results of multinomial logistic regression analyses. Bold indicates $p < 0.05$.

Conclusion

This study underscores the profound impact of comorbid depression and anxiety on orofacial pain intensity, sleep propensity, jaw overuse behavior, jaw functional limitations, and OHRQoL in patients with TMDs. Approximately one-third of the participants exhibited anxious depression, which was associated with the worst outcomes across all variables assessed. The findings also highlight the correlations between pain intensity, jaw functional limitation, and OHRQoL, emphasizing the intertwined nature of physical symptoms and quality of life in TMD patients. Importantly, comorbid depression and anxiety significantly increase the likelihood of painful TMD subtypes, emphasizing the need to incorporate psychological assessments into routine TMD management. An interprofessional, multimodal approach that includes PPIs may help alleviate the physical and psychosocial challenges faced by TMD patients with substantial psychological distress, aligning with global calls to integrate mental health care into chronic pain services. Future longitudinal research with diverse populations is necessary to explore causal pathways and ensure the broader applicability of the findings.

Data availability

Data for this study are available from the corresponding author on reasonable request.

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Author contributions

A.U.Y. contributed to conceptualization, methodology, visualization, formal analysis, validation, resources, project administration, and writing—original draft. Y.Z. contributed to methodology, investigation, data curation, formal analysis, validation, software, resources, and writing—review & editing. T.L., Y.L., Y.L. and P.W. contributed to investigation, data curation, resources, and writing—review & editing. S.D. and X.X. contributed to conceptualization, methodology, investigation, data curation, formal analysis, validation, resources, project administration, funding acquisition, and writing—review & editing.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval

The study was conducted according to the guidelines of the Declaration of Helsinki and was approved by the Institutional Review Board at the West China Hospital of Stomatology, Sichuan University (Reference: WCHSIRB-D-2022-212).

Informed consent

Informed consent was obtained from all participants involved in the study.

Additional information

Correspondence and requests for materials should be addressed to S.D. or X.X.

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