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RESEARCH

DC/TMD Axis I diagnostic subtypes in TMD patients from Confucian heritage cultures: a stratified reporting framework

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Abstract

Objectives This study proposed a conceptual framework for reporting Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) Axis I conditions and investigated the prevalence of TMD subtypes/categories in patients from Confucian heritage cultures. Variances in gender, age, and TMD chronicity between Chinese (CN) and Korean (KR) patients were also explored.
Materials and methods Subjects were recruited from consecutive patients seeking care at two University-based centers in Beijing and Seoul. Eligible patients completed a demographic survey as well as the DC/TMD Symptom Questionnaire and were clinically examined according to the DC/TMD methodology. Axis I diagnoses were subsequently rendered with the DC/TMD algorithms and documented using the stratified reporting framework. Statistical evaluations were performed with chi-square, Mann–Whitney *U* tests, and logistic regression analysis ($\alpha = 0.05$).
Results Data of 2008 TMD patients (mean age 34.8 ± 16.2 years) were appraised. Substantial differences in female-to-male ratio (CN > KR), age (KR > CN), and TMD duration (KR > CN) were observed. Ranked frequencies of the most common Axis I diagnoses were: CN – disc displacements (69.7%) > arthralgia (39.9%) > degenerative joint disease (36.7%); KR – disc displacements (81.0%) > myalgia (60.2%) > arthralgia (56.1%). Concerning TMD categories, notable differences in the prevalence of intra-articular (CN 55.1% > KR 15.4%) and combined (KR 71.8% > CN 33.4%) TMDs were discerned.
Conclusions Though culturally similar, the two countries require disparate TMD care planning/prioritization. While TMJ disorders in children/adolescents and young adults should be emphasized in China, the focus in Korea would be on TMD pain in young and middle-aged adults.
Clinical relevance Besides culture, other variables including socioeconomic, environmental, and psychosocial factors can influence the clinical presentation of TMDs. Chinese and Korean TMD patients exhibited significantly more intra-articular and combined TMDs respectively.

Keywords Temporomandibular joint disorders · Diagnosis · Prevalence · Pain · Intra-articular · Classification

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Introduction

Temporomandibular disorders (TMDs) are a diverse group of musculoskeletal conditions characterized by pain and/or dysfunction of the temporomandibular joints (TMJs), muscles of mastication, and supporting structures [1, 2]. They are a significant public health problem affecting up to 7% of adolescents and 16% of adults [2–4]. TMDs, especially when painful, have been shown to impair both general and oral health-related quality of life [5, 6]. Conversely, TMD interventions can improve the life quality of patients with TMDs [7]. Women, particularly those of reproductive age, are more susceptible to TMDs and constitute up to 80% of all TMD patients [8, 9]. The biopsychosocial model for TMDs has been corroborated by prospective cohort, case–control, as well as cross-sectional studies [10–12]. Risk factors for TMDs include sex hormones, trauma, parafunctional habits, emotional distress, and somatization [2, 13, 14].

The Research Diagnostic Criteria for TMDs (RDC/TMD), introduced in 1992, was the standard for diagnosing and classifying TMDs for over two decades till it was replaced by the Diagnostic Criteria for TMDs (DC/TMD) in 2014 [15, 16]. It is based on the biopsychosocial model and is divided into two axes: Axis I – clinical TMDs and Axis II – psychosocial status and pain-related disability. Though Axis I of the RDC/TMD was found to be reliable, its validity was below the target sensitivity of ≥ 0.70 and specificity of ≥ 0.95 [17]. The evidence-based DC/TMD protocol has valid criteria for differentiating common pain-related TMDs (sensitivity ≥ 0.86 and specificity ≥ 0.98) and for disc displacement without reduction with limited opening (sensitivity of 0.80 and specificity of 0.97). With its improved validity, the DC/TMD can be applied in both research and clinical settings [16]. Despite their commonalities, the taxonomic classification structure of the RDC/TMD and DC/TMD varies noticeably. While the RDC/TMD organizes common TMDs into three groups, specifically Group 1 – muscle disorders, Group II – disc displacements, and Group III – other joint conditions, the DC/TMD classifies them into pain-related (PT) and intra-articular (IT) TMDs. The pain-related conditions comprise arthralgia, myalgia (local myalgia, myofascial pain, and myofascial pain with referral), and headache attributed to TMD, while intra-articular disorders include four types of TMJ disc displacements, degenerative joint disease, and subluxation. Considering the numerous permutations and combinations possible, it is paramount that reporting of the varied DC/TMD Axis I subtypes be standardized so that comparable data across different research settings (clinical versus non-clinical), as well as study designs (observational versus interventional), can be generated. Moreover, this will also increase data homogeneity, facilitate data-pooling, and statistical assessments during systematic reviews and meta-analyses [18]. Thus far, researchers had attempted to divide TMD subtypes by chronicity (acute versus chronic), anatomy (TMJs versus masticatory muscles), site (intra- versus extra-articular), function (functional versus dysfunctional), and symptom (painful versus non-painful) [19–21]. As painful TMDs, especially when chronic, appear to have greater psychosocial and other negative effects, the classification of TMDs by pain, as advocated by the DC/TMD, is more clinically relevant [22–24].

Confucian heritage cultures (CHCs) that encompass East Asian countries like China, Korea, and Japan are those founded on the teachings of Confucius (a sixth-century Chinese philosopher, politician, and sage) [25]. CHCs emphasize group orientation, hierarchal harmony, influential relationships/networks (“guanxi”), as well as social stature/recognition (“mianzi”) [26]. These values are underpinned by the pursuit of personal excellence/achievements through self-effort and are often associated with high levels of emotional distress and poor psychological well-being [27, 28]. Due to the stigma of mental illness, East Asians tend to express and communicate distress via somatic symptoms including TMDs. This may lead to distinct patterns of TMD prevalence when compared to other countries with different cultural backgrounds [29–32]. The interconnections between TMDs, somatization. and emotional distress are well established leading some to posit that TMDs are a form of central sensitivity syndromes [14, 32–34].

Information on the prevalence of TMD diagnostic subtypes among TMD patients is essential for establishing disease burden, identifying care priorities, enabling service planning/financing, and developing clinical practice guidelines and healthcare policies [35]. The objectives of this work were thus to recommend a conceptual framework for reporting DC/TMD Axis I conditions and to examine the prevalence of TMD subtypes/categories in patients from CHCs. Additionally, variances in gender, age, and chronicity were also contrasted between Chinese and Korean patients. The study hypotheses were as follows: (a) the stratified reporting framework offered a systematic and pragmatic way of clustering Axis I diagnostic subtypes and their combinations, (b) the frequency of pain-related and intra-articular conditions was comparable, and (c) variations in gender, age, and TMD chronicity were insignificant between Chinese and Korean TMD patients.

Materials and methods

Study participants

Ethical approvals for this work were granted by the relevant Institutional Review Boards in China and Korea (reference numbers: PKUSSIRB-201732009 and ERI22001).

Subjects were recruited between 1 Jan 2019 and 31 Dec 2021 from consecutive "first-visit" patients seeking care at two University-based TMD centers in the capital cities of China (Beijing) and Korea (Seoul). A target sample size of approximately 1000 consecutive TMD patients from both centers was set to enhance accuracy and representativeness [36]. Patients who were proficient in Chinese or Korean language presenting with TMD signs and/or symptoms, specifically orofacial pain, headaches, TMJ sounds, as well as closed and open locking, were included. Those with prior orofacial trauma, craniofacial abnormalities, narcotics abuse, debilitating psychological or physical conditions, illiteracy, or cognitive impairments were duly excluded. The relevant informed consents were obtained where applicable and patients were directed to complete a demographic and medical survey, the official Chinese and Korean versions of the DC/TMD Symptom Questionnaire (SQ), and other site-determined measures. The DC/TMD SQ, a self-reported instrument, provided the necessary history for rendering specific Axis I diagnoses. It consists of 14 items assessing pain symptoms involving the jaws, temples, and ears, headache, jaw noises, and locking over 30 days.

TMD diagnosis

Comprehensive TMD examinations were conducted according to the DC/TMD protocol by orofacial pain/TMD or oral medicine specialists who were trained, calibrated, and proficient in the DC/TMD methodology [16]. Clinical evaluations included the assessment of pain localization, palpation pain, jaw movements (lateral, protrusion, and mouth opening), movement pain, and TMJ sounds. As only one TMJ intra-articular condition has adequate diagnostic validity for clinical use, panoramic radiographs and/or adjunctive diagnostic imaging, such as cone-beam computed tomography (CBCT) and magnetic resonance imaging (MRI), were performed to verify clinical evaluations. More specifically, panoramic radiographs and CBCTs were prescribed when the DC/TMD protocol suggested no TMJ pathology and degenerative joint disease respectively. MRIs were prescribed only in the presence of prolonged restricted mouth opening or suspected malignancy. CBCT and MRI assessments were conducted by dental radiologists at both sites. DC/TMD Axis I diagnoses and subtypes were subsequently derived based on symptom history, clinical, and imaging findings using the DC/TMD algorithms, and diagnostic tree.

Stratified reporting framework

The stratified reporting framework was based on the two principal diagnostic groups of the DC/TMD as well as considerations for overlapping and single/multiple TMD subtypes (Table 1). The tiered approach offers a methodical and practical way of clustering Axis I subtypes (including subordinate types) and their combinations depending on the nature of research (epidemiology, behavioral, health services, and clinical trials) and clinical investigation (prevention, screening, diagnostic, treatment, behavior, and quality of life trials), in addition to the anticipated "exactness" of reporting required. At the global level (Level 1), Axis I subtypes are reported under PT and IT without provisions for overlaps or "double/multiple counting." Level 1 reporting is indicated when the incidence and prevalence of discrete Axis I conditions are sought as in epidemiological studies. A classic example would be assessing the types and frequency of TMDs in a target population like "women with menstrual disorders" [37]. To reduce the number of conditions, related subordinate types could be merged. For instance, the four forms of disc displacements can be combined into two (disc displacements with and without reduction) or a single subtype (disc displacements). "Double-counting" is disallowed in Level 2 and Level 3 reporting, minimizing the inappropriate inference of results such as the overrepresentation of disease prevalence. Level 2 reporting involves the categorization of Axis I subtypes into PT, IT, and combined TMDs (CT – PT plus IT) and is particularly useful for clinical investigations including screening and quality of life trials [10, 19, 38, 39]. Though overlapping principal diagnoses are contemplated, single and multiple subtypes are not distinguished for each of the three major TMD categories. Should epidemiological studies be carried out without imaging, Level 2 reporting is also recommended given the low specificity of clinical procedures for diagnosing disc displacements with reduction/without reduction without limited opening and degenerative joint diseases [16]. Level 2 reporting is also applicable to TMD symptoms and can be employed in both clinical and nonclinical samples [40, 41].

Level 3 represents the most eclectic reporting and entails both single and multiple subtypes for each of the three major TMD categories. It is usually indicated when PT and/or IT are to be explored in depth as in diagnostic imaging studies [20, 42]. Both Axis I diagnostic subtypes and their subordinates are considered in varied arrangements granting substantial flexibility in the reporting structure. An example of Level 3 "single combined TMDs" would be TMJ osteoarthritis where a single pain-related condition (arthralgia) is paired with a single intra-articular condition (degenerative joint disease). Nevertheless, TMJ osteoarthritis is often associated with TMJ disc displacements with and without reduction giving rise to "multiple combined TMDs" [43]. As intra-articular disorders can occur bilaterally, the joint related to the patient's primary complaint is documented. If the primary complaint involves both TMJs, the joint presenting more intra-articular conditions is reported accordingly.

Table 1 The stratified reporting framework for DC/TMD Axis I subtypes

Level	Description	Stratification	Rubrics
Level 1	Global stratification of TMD subtypes based on the two principal DC/TMD diagnostic groups	**Pain-related TMDs (PT)** • **Arthralgia (A)** • **Myalgia (M)** *Local myalgia* *Myofascial pain* *Myofascial pain with referral* • **Headache attributed to TMD (H)** **Intra-articular TMDs (IT)** • **Disc displacements (D)** *D with reduction (DwR)* DwR DwR with intermittent locking *D without reduction (Dw/oR)* Dw/oR with limited opening Dw/oR without limited opening • **Degenerative joint disease (J)** • **TMJ subluxation (S)**	Reporting without considering overlapping diagnostic subtypes
Level 2	Stratification of TMD subtypes founded on three major TMD categories	**Pain-related TMDs (PT)** • Presence of ≥ 1 pain-related conditions, no intra-articular conditions **Intra-articular TMDs (IT)** • Presence of ≥ 1 intra-articular conditions, no pain-related conditions **Combined TMDs (CT)** • Presence of ≥ 1 PT + ≥ 1 IT	Reporting with consideration of overlapping diagnostic subtypes but no differentiation of single or multiple conditions
Level 3	Stratification of TMD subtypes founded on the three major TMD categories, factoring single and multiple conditions	**Pain-related TMDs (PT)** • Presence of single PT (A, M, H) • Presence of multiple PT (AM, AH, MH, AHM) **Intra-articular TMDs (IT)** • Presence of single IT (D, J, S) • Presence of multiple IT (DJ, DS, JS, DJS) **Combined TMDs (CT)** • Presence of single CT (1 PT + 1 IT) • Presence of multiple CT (1 PT + ≥ 2 IT or 1 IT + ≥ 2 PT or all other permutations)	Reporting with consideration of overlapping diagnostic subtypes as well as single/multiple conditions Subject reporting is sequenced by primary complaints followed by the joint with more conditions should bilateral joints are symptomatic

Boldface indicates principal groups and major subtypes, while italics indicate subordinate types. A = arthralgia, M = myalgia; H = headaches attributed to TMDs; D = disc displacement; J = degenerative joint disease; and S = TMJ subluxation

Statistical analyses

The IBM SPSS Statistics for Windows software Version 26.0 (IBM Corporation, Armonk, NY, USA) was used for statistical analyses with the significance level set at 0.05. Qualitative data are reported as frequencies with percentages and evaluated using chi-square and post hoc Z tests with Bonferroni's correction where applicable. While patients' age was grouped into ≤ 17 (children/adolescents), 18–44 (young adults), 45–64 (middle-aged adults), and ≥ 65 (old adults) years old, TMD chronicity was divided into ≤ 3 months (acute) and > 3 months (chronic) [44, 45]. The normality of quantitative data was assessed with the Shapiro–Wilk test and reported as means/medians with standard deviations (SD)/interquartile ranges). As age and disease duration were not normally distributed, they were assessed using the Mann–Whitney U test. Univariate and multivariate logistic regression analyses were subsequently performed to establish the demographic risk factors for the three categories of TMDs, namely PT, IT, and CT.

Results

Table 2 details the demographic characteristics of all ($n = 2008$), Chinese [CN] ($n = 1006$), and Korean [KR] ($n = 1002$) TMD patients. The mean age of the overall sample was 34.8 ± 16.2 years and significant variance in age was discerned between Chinese (29.8 ± 13.8 years) and Korean (39.9 ± 16.9 years) subjects. For both TMD cohorts, a predominance of women was observed. Women constituted 80.7% and 70.0% of the Chinese and Korean patients accordingly. A substantial difference in TMD duration was also noted between Chinese (12.6 ± 26.3 months) and Korean (36.0 ± 65.2 months) subjects.

Table 3 presents the Level 1 reporting for the TMD subjects. Ranking of the major PT subtypes in order of prevalence was CN – arthralgia (39.9%) > myalgia (8.8%) > headache (1.1%); KR – myalgia (60.2%) > arthralgia (56.1%) > headache (19.1%). Significant differences in the frequency of arthralgia, myalgia, and headache were detected (KR > CN). The prevalence of "any pain-related disorders" in Korean patients (84.6%) was 1.9 folds that of their Chinese counterparts (44.9%). Ranked prevalence of the major IT subtypes was CN – disc displacements (69.7%) > degenerative joint disease (36.7%) > TMJ subluxation (1.6%); KR – disc displacements (80.1%) > degenerative joint disease (36.7%) > TMJ subluxation (1.4%). Significant differences in frequency were noted for disc displacements, specifically disc displacement with reduction (KR > CN), disc displacement with reduction with intermittent locking (CN > KR), and disc displacement without reduction without limited opening (CN > KR). The prevalence of "any intra-articular disorders" were comparable between Chinese (88.5%) and Korean (87.1%) subjects.

Level 2 reporting for all TMD patients and individual countries is reflected in Tables 4 and 5. When patients were pooled (Table 4), significant differences in the prevalence of the three TMD categories were women/men – CT, IT > PT; children/adolescents – IT > CT, PT; young adults – CT > IT > PT; middle-aged adults – CT, PT > IT; and older adults – CT > PT > IT. For all TMD categories, women (63.7–78.7%) and young adults (54.7–72.5%) formed the majority of patients. Significant differences in the distribution of TMD categories were also observed for acute (CT, IT > PT) and chronic (CT > IT > PT) TMDs.

Table 2 Demographics of the Chinese and Korean TMD patients

Variables	All TMD patients	Chinese TMD patients	Korean TMD patients	p-value
Total				
n (%)	2008 (100)	1006 (50.1)	1002 (49.9)	-
Gender				
Women	1513 (75.3)	812 (80.7)	701 (70.0)	***< 0.001***
Men	495 (24.7)	194 (19.3)	301 (30.0)	
Age				
Mean ± SD	34.8 ± 16.2	29.8 ± 13.8	39.9 ± 16.9	***< 0.001***
Median (IQR)	30.0 (23.0–44.0)	27.0 (20.0–35.0)	34.0 (26.0–53.0)	
Duration of TMDs (months)				
Mean ± SD	24.3 ± 51.0	12.6 ± 26.3	36.0 ± 65.2	***< 0.001***
Median (IQR)	4.0 (1.0–24.0)	3.0 (0.3–12.0)	7.5 (1.0–36.0)	

SD, standard deviation; *IQR*, interquartile range. Results of *chi-square and ^Mann–Whitney U tests. Bold indicates $p < 0.05$

Table 3 Level 1 reporting for the Chinese and Korean TMD patients

Diagnostic category	DC/TMD Axis I subtypes	All TMD patients *n* (%)	Chinese patients *n* (%)	Korean TMD patients *n* (%)	*p*-value*
Total		2008 (100)	1006 (100)	1002 (100)	
Pain-related TMDs	Arthralgia (A)	963 (48.0)	401 (39.9)	562 (56.1)	**< 0.001**
	Myalgia (M)	692 (34.5)	89 (8.8)	603 (60.2)	**< 0.001**
	Local myalgia	540 (26.9)	20 (2.0)	520 (51.9)	**< 0.001**
	Myofascial pain	134 (6.7)	68 (6.8)	66 (6.6)	0.877
	Myofascial pain with referral	18 (0.9)	1 (0.1)	17 (1.7)	**< 0.001**
	Headache attributed to TMDs (H)	202 (10.1)	11 (1.1)	191 (19.1)	**< 0.001**
	Any pain-related disorders	1300 (64.7)	452 (44.9)	848 (84.6)	**< 0.001**
Intra-articular TMDs	Disc displacements (D)	1513 (75.3)	701 (69.7)	812 (81.0)	**< 0.001**
	D with reduction (DwR)	905 (45.0)	280 (27.9)	625 (62.4)	**< 0.001**
	DwR	794 (39.5)	205 (20.4)	589 (58.8)	**< 0.001**
	DwR with intermittent locking	111 (5.5)	75 (7.5)	36 (3.6)	**< 0.001**
	D without reduction (Dw/oR)	623 (31.0)	426 (42.3)	197 (19.7)	**< 0.001**
	Dw/oR with limited opening	313 (15.6)	160 (15.9)	153 (15.3)	0.695
	Dw/oR without limited opening	310 (15.4)	266 (26.4)	44 (4.4)	**< 0.001**
	Degenerative joint disease (J)	737 (36.7)	369 (36.7)	368 (36.7)	0.983
	TMJ subluxation (S)	30 (1.5)	16 (1.6)	14 (1.4)	0.721
	Any intra-articular disorders	1763 (87.8)	890 (88.5)	873 (87.1)	0.358

Results of *chi-square test. Bold indicates $p < 0.05$

Table 4 Level 2 reporting for all TMD patients

Variables	Total *n* (%)	Pain-related TMDs *n* (%)	Intra-articular TMDs *n* (%)	Combined TMDs *n* (%)	*p*-value* Post hoc
Gender					
Women	1513 (100)	156 (10.3)	527 (34.8)	830 (54.9)	***< 0.001*** CT, IT > PT
Men	495 (100)	89 (18.0)	181 (36.5)	225 (45.5)	***< 0.001*** CT, IT > PT
Age					
17 ≤ years	175 (100)	6 (3.4)	121 (69.1)	48 (27.4)	***< 0.001*** IT > CT, PT
18–44 years	1334 (100)	134 (10.0)	513 (38.5)	687 (51.5)	***< 0.001*** CT > IT > PT
45–64 years	365 (100)	73 (20.0)	52 (14.2)	240 (65.8)	***< 0.001*** CT, PT > IT
≥ 65 years	134 (100)	32 (23.9)	22 (16.4)	80 (59.7)	***< 0.001*** CT > PT > IT
Chronicity					
Acute (≤ 3 months)	843 (100)	112 (13.3)	359 (42.6)	372 (44.1)	***< 0.001*** CT, IT > PT
Chronic (> 3 months)	1165 (100)	133 (11.4)	349 (30.0)	683 (58.6)	***< 0.001*** CT > IT > PT

Results of *chi-square and post hoc *Z* tests with Bonferroni correction (where applicable). Bold indicates $p < 0.05$

Prevalence ranking of the three TMD categories (Table 5) was CN – IT (55.1%) > CT (33.4%) > PT (11.5%); KR – CT (71.8%) > IT (15.4%) > PT (12.9%). When countries were contrasted, more Chinese female and Korean male patients were diagnosed with PT, IT, and CT. Significantly more Korean old adults had PT, IT, and CT, whereas more Chinese children/adolescents suffered from IT and CT. While more Chinese young adults presented with IT, more Korean young

Table 5 Level 2 comparisons between Chinese ($n = 1006$) and Korean ($n = 1002$) TMD patients

Diagnostic category	Variables	Total *n* (%)	Chinese (CN) *n* (%)	Korean (KR) *n* (%)	*p*-value*
Pain-related TMDs (PT)	Patients with PT	245 (100)	116 (47.3)	129 (52.7)	0.406
	Gender				
	Women	156 (100)	83 (53.2)	73 (46.8)	0.423
	Men	89 (100)	33 (37.1)	56 (62.9)	**0.015**
	Age				
	17 ≤ years	6 (100)	5 (83.3)	1 (16.7)	NA
	18–44 years	134 (100)	68 (50.7)	66 (49.3)	0.863
	45–64 years	73 (100)	33 (45.2)	40 (54.8)	0.413
	≥ 65 years	32 (100)	10 (31.3)	22 (68.8)	**0.034**
	Chronicity				
	Acute (≤ 3 months)	112 (100)	51 (45.5)	61 (54.5)	0.345
	Chronic (> 3 months)	133 (100)	65 (48.9)	68 (51.1)	0.795
Intra-articular TMDs (IT)	Patients with IT	708 (100)	554 (78.2)	154 (21.8)	**< 0.001**
	Gender				
	Women	527 (100)	435 (82.5)	92 (17.5)	**< 0.001**
	Men	181 (100)	119 (65.7)	62 (34.3)	**< 0.001**
	Age				
	17 ≤ years	121 (100)	121 (100)	0	**< 0.001**
	18–44 years	513 (100)	400 (78.0)	113 (22.0)	**< 0.001**
	45–64 years	52 (100)	29 (55.8)	23 (44.2)	0.405
	≥ 65 years	22 (100)	4 (18.2)	18 (81.8)	**0.003**
	Chronicity				
	Acute (≤ 3 months)	359 (100)	283 (78.8)	76 (21.2)	**< 0.001**
	Chronic (> 3 months)	349 (100)	271 (77.7)	78 (22.3)	**< 0.001**
Combined TMDs (CT)	Patients with CT	1055 (100)	336 (31.8)	719 (68.2)	**< 0.001**
	Gender				
	Women	830 (100)	294 (35.4)	536 (64.6)	**< 0.001**
	Men	225 (100)	42 (18.7)	183 (81.3)	**< 0.001**
	Age				
	17 ≤ years	48 (100)	48 (100)	0	**< 0.001**
	18–44 years	687 (100)	213 (31.0)	474 (69.0)	**< 0.001**
	45–64 years	240 (100)	62 (25.8)	178 (74.2)	**< 0.001**
	≥ 65 years	80 (100)	13 (16.3)	67 (83.7)	**< 0.001**
	Chronicity				
	Acute (≤ 3 months)	372 (100)	166 (44.6)	206 (55.4)	**0.038**
	Chronic (> 3 months)	683 (100)	170 (24.9)	513 (75.1)	**< 0.001**

Results of *chi-square test. Bold indicates $p < 0.05$. NA denotes not applicable due to inadequate sample size

and middle-aged adults had CT. Considerable differences in acute/chronic IT and CT were also observed between the two TMD cohorts (acute/chronic IT – CN > KR: acute/chronic CT – KR > CN). Table 6 shows the outcomes of multivariate logistic regression analyses. While being Chinese increased the odds of IT by 5.7 times, being Korean increased the probability of PT by 34% and CT by 5.7 times. In addition, being women increased the likelihood of PT, IT, and CT by 2.0, 1.5, and 2.1 times correspondingly. The influence of age, though significant for PT and IT, was nominal.

Discussion

This study is the first to provide a structured framework for reporting DC/TMD Axis I conditions and represents one of the largest (in terms of sample size) cross-national TMD prevalence research to date. The first research hypothesis was supported as a rational and practical method of clustering DC/TMD Axis I subtypes was established. The second and third research hypotheses were duly rejected as significant variations in the

Table 6 Demographic risk factors for the three categories of TMDs

	Univariate		Multivariate	
Variables	Odds ratio (95% CI)	*p*-value*	Odds ratio (95% CI)	*p*-value^
Pain-related TMDs				
Ethnicity				
Chinese	Reference	-	Reference	-
Korean	1.13 (0.87–1.48)	0.358	1.34 (1.02–1.83)	0.037
Gender				
Women	1.91 (1.44–2.53)	**< 0.001**	2.01 (1.50–2.69)	**< 0.001**
Men	Reference	-	Reference	-
Age	1.03 (1.02–1.04)	**< 0.001**	1.03 (1.02–1.04)	**< 0.001**
Intra-articular TMDs				
Ethnicity				
Chinese	6.75 (5.46–8.34)	**< 0.001**	5.69 (4.55–7.11)	**< 0.001**
Korean	Reference	-	Reference	-
Gender				
Women	0.93 (0.75–1.14)	0.483	1.47 (1.15–1.88)	**0.002**
Men	Reference	-	Reference	-
Age	0.96(0.95–0.96)	**< 0.001**	0.97 (0.96–0.98)	**< 0.001**
Combined TMDs				
Ethnicity				
Chinese	Reference	-	Reference	-
Korean	5.07 (4.19–6.13)	**< 0.001**	5.70 (4.67–6.94)	**< 0.001**
Gender				
Women	1.46 (1.19–1.79)	**< 0.001**	2.08 (1.65–2.61)	**< 0.001**
Men	Reference	-	Reference	-
Age	1.02 (1.01–1.03)	**< 0.001**	-	-

Results of univariate and multivariate logistic regression analysis. Bold indicates $p < 0.05$

prevalence of TMD subtypes/categories as well as gender, age, and chronicity distributions were discerned between Chinese and Korean patients.

Demographic variances

Though women were predominant among both TMD populations, a notable difference in female-to-male ratios (CN – 4.0; KR – 2.3) was observed. Women have a two to three times greater risk of TMDs than men and the gender disparity was attributed to a multitude of factors including sex differences in biology, social functions, emotional distress, pain sensitivity, perception/modulation, coping, and health-seeking [3, 8, 46]. The reason for the greater proportion of women among Chinese TMD patients, despite the roughly balanced gender ratio of both countries (CN – 0.94; KR – 0.99), is not known [47]. Nevertheless, general health and chronic pain problems such as low back and menstrual/genital pain, socioeconomic, environmental, and psychosocial factors could be involved [8, 11, 12, 48]. The mean age of the Chinese and Korean TMD patients was consistent with the range reported for other countries and cultures (30.2–39.4 years) [3]. While young adults featured prominently in the two countries, Chinese TMD patients were often younger. The age disparity cannot be explained by differences in healthcare systems as TMD treatment in both countries is generally not covered by government health insurance in whole and entail out-of-pocket payment. Instead, it could be contributed by possible greater public/professional TMD awareness, earlier first-onset TMD signs/symptoms, and TMD treatment-seeking or referrals. As Korean TMD patients were older when they first sought treatment, the significantly longer disease duration conveyed was anticipated as the peak development of TMD signs/symptoms normally occurs during young adulthood [49].

Prevalence of discrete TMD subtypes

Although the DC/TMD is internationally accepted and had been translated into more than 30 languages, explicit descriptions of the frequency of distinct DC/TMD Axis I subtypes for TMD patient populations are still not available in the literature [11]. The lack of a standardized strategy for reporting DC/TMD Axis I data could play a part and was addressed by the current work [3]. Manfredini et al. in their systematic review of RDC/TMD Axis I findings found 15 studies involving TMD patient populations from 8 countries accounting for a total of 3463 subjects. The frequency of the different Axis I diagnoses varied markedly among studies. Overall prevalence of 45.3% for muscle disorders/myalgia (range 1.9–50.6%), 41.1% for disc displacements with (range 20.0–44.2%) and without (range 0–12.8%) reduction, and 30.1% for joint disorders primarily arthralgia (range 13.0–58.0%) and/or degenerative joint disease (range 0–55.6%) was attained [3].

The prevalence of myalgia in Chinese patients was within the documented range whereas that for Korean subjects exceeded the highest reported frequency by about 10%. However, the prevalence of arthralgia in the two TMD cohorts was congruous with the findings from other countries. While TMJ arthralgia is often characterized by well-defined localized inflammatory processes, the pathophysiology of myalgia is less understood and varying combinations of genetic predisposition, central sensitization, peripheral nervous system dysregulation, pain modulatory system imbalance, and masticatory muscle hyperactivity secondary to emotional distress were implicated [50]. Korean TMD patients appear more prone to myalgia and this could be partly associated with "Hwa-Byung" (HB), an anger-related culture-bound syndrome specific to Korea. HB, which means "anger or fire disease," affects 4.1% of the Korean general population, mostly middle-class and middle-aged women [51]. HB is characterized by symptoms of partially suppressed anger and somatic/anxiety-based manifestations of partially expressed anger including heat sensation, palpitations, indigestion, fatigue, insomnia, panic, headaches, and generalized body pains [51, 52].

The frequencies of disc displacements for both Chinese and Korean TMD patients were mostly greater than the rates reported for other countries [3]. Of concern is the rather high occurrence of disc displacement without reduction in Chinese patients (42.3%) which has been linked to degenerative TMJ changes [53]. However, the prevalence of degenerative joint disease was still within the range specified in other countries. For both TMD cohorts, disc displacements were the most common Axis I diagnoses (69.7–81.0%). They were followed by arthralgia (39.9%) and degenerative joint disease (36.7%) for Chinese, and myalgia (60.2%) and arthralgia (59.1%) for Korean subjects correspondingly. Chinese patients have a substantially greater prevalence of disc displacement without reduction whilst their Korean counterparts have significantly higher frequencies of painful TMDs and disc displacement with reduction. Besides socioeconomic, environmental, and psychosocial factors, the variations could also be contributed by lifestyle variables, such as physical activity and smoking [11, 54, 55]

Prevalence of TMD categories and demographic risk factors

When data were pooled, both women and men had a higher prevalence of CT and IT when compared to PT. This same trend was also detected for young adults but not for children/adolescents and middle-aged/old adults. While the prevalence of IT was higher than CT and PT in children/adolescents, the frequencies of CT and PT were greater than IT in middle-aged/old adults. Therefore, children/adolescents and middle-aged/old adults tend to present with TMD dysfunction (non-painful IT) and pain (CT and PT) respectively. Findings corroborated those of Western TMD patients based on the RDC/TMD and two distinct age peaks were identified with TMJ degenerative joint disease as the potential marker [56, 57].

For all TMD categories, the greater proportion of Chinese female and Korean male patients corresponded to the higher female-to-male ratio of the Chinese TMD cohort. Excluding gender and old adults, variances in PT were insignificant between the two countries. While children/adolescents made up 21.8% and 14.3% of the Chinese TMD patients with IT and CT, all Korean patients with these conditions were ≥ 18 years old. The putative reasons for the younger Chinese TMD patients were deliberated earlier and this phenomenon was congruent with the high occurrence of TMD pain (14.8%) among Chinese adolescents when contrasted to their Western age-matched counterparts (5.1%) [58]. Although no significant differences were detected for acute/chronic PT, more Chinese and Korean TMD patients presented with acute/chronic IT and CT respectively. This may be explained by the greater prevalence of painful TMDs among adult Korean patients as the occurrence of disc displacements was high in both TMD cohorts. Outcomes of multivariate analyses, where confounders are controlled, confirmed the influence of gender and ethnicity on the occurrence of PT, IT, and CT. The female gender amplified the risk of non-painful intra-articular (IT) and painful (PT and CT) TMDs by up to 2 times and reinforced the findings of prior research [8]. Ethnicity appeared to have a greater effect than gender with being Chinese increasing the risk of IT by 5.7 times and being Korean raising the prospect of PT by 34% and CT by 5.7 times. The influence of age was minor when compared to gender and ethnicity. Though the prevalence of orofacial pain including TMDs escalates with age, the increase was found to be greater in women than men [59].

Study limitations

The present work had several limitations. First, the stratified DC/TMD reporting framework while operable must be universally adopted before global data homogeneity can be achieved. The framework should also be expanded to include less common but clinically significant TMDs such as condylar ankylosis, fractures, and hyperplasia [60]. Second, not all CHC countries were engaged and only TMD populations in the capital cities were assessed. Future research could entail the incorporation of other CHC countries as well as TMD samples from both urban and rural zones. However, this is subject to the availability of psychometrically tested DC/TMD translations and trained/calibrated examiners. Third, the data gathered from the two TMD cohorts, though pertinent from a clinical viewpoint, may not be relevant to all provinces and the general population. General population studies are necessary to ascertain TMD disease burdens which could explain some of the variances in the frequencies of DC/TMD Axis I findings. Supplementary studies in other provincial hospitals and the general population are thus desirable. Forth, inter-examiner reliability across the two sites was not carried out given the global adoption of the DC/TMD methodology and MRIs were not routinely performed on all patients due to their high cost. The principal imaging modalities were panoramic radiographs and/or CBCTs. Panoramic radiographs were employed mainly for screening purposes due to their relatively small radiation doses and low specificity/sensitivity when compared to CBCTs, which were used to confirm degenerative joint disease [61]. Although CBCT and MRI assessments were conducted by dental radiologists at both sites, the diagnostic criteria could not be standardized due to the lack of universally accepted imaging benchmarks [62]. Lastly, socioeconomic, environmental, and psychosocial variables while important were beyond the scope of the present work. These factors were evaluated in prior publications and have also been planned for future ones [10, 20, 44].

Conclusion

A standardized strategy for reporting DC/TMD Axis I findings was established. The stratified framework provides for the documentation of overlapping and single/multiple TMD subtypes and their varying combinations. Application of the DC/TMD protocol together with the tiered reporting framework will increase global data homogeneity and consequently facilitate cross-study comparisons as well as enhance the quality of synthesized results during meta-analyses. Chinese TMD patients comprised a greater proportion of women and were generally younger than their Korean counterparts. Ranked frequency of the most common Axis I diagnoses was disc displacements (69.7%), arthralgia (39.9%), and degenerative joint disease (36.7%) for Chinese TMD patients, and disc displacements (81.0%), myalgia (60.2%), and arthralgia (59.1%) for Korean patients. Regarding TMD categories, Chinese TMD patients had a notably higher prevalence of intra-articular TMDs (55.1% versus 15.4%), while Korean patients presented a greater frequency of combined TMDs (71.8% versus 33.4%). Nevertheless, the occurrence of pain-related TMDs was comparable (11.5–12.9%). Gender and ethnicity influenced the prevalence of TMDs more than age. Although culturally similar, disparate TMD care planning/prioritization and disease surveillance are required for the two countries. While the emphasis in China TMD patients would be on TMJ disorders in children/adolescents and young adults, the focus in Korea should be on TMD pain in young and middle-aged adults.

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Author contribution J.P., S.K., B.L., J.L., and K.F collected the data. A.Y. initiated the project and drafted the main manuscript text. J.L. conducted statistical analysis and prepared tables. J.P. and K.F. critically revised the main manuscript. All authors reviewed and approved the final manuscript.

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Data availability The data that support the findings of this study are available on reasonable request from the corresponding author. The data are not publicly available due to ethical reasons that could compromise the participants.

Declarations

Ethical approval This work was approved by the Biomedical Institutional Review Boards at the School of Stomatology, Peking University (PKUSSIRB-201732009) and Seoul National University Dental Hospital (ERI22001).

Consent to participate The applicable informed consent was obtained from the study subjects or their parent/guardian in China whereas exemption of informed consent was accorded in Korea.

Competing interests The authors declare no competing interests.

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