Review

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Temporomandibular disorder and headache prevalence: A systematic review and meta-analysis

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Abstract

Background: Temporomandibular disorders (TMD) and headaches are prevalent among the global population. Patients often suffer from both conditions, and they are likely to be associated in a bidirectional way. However, the nature of the association remains unclear. Understanding the epidemiological aspects of the relationship between these conditions could have important clinical implications.

Objective: To evaluate the prevalence of headaches in TMD patients as well as the prevalence of TMD in patients who suffer from headaches.

Method: A systematic literature search was conducted using electronic databases. Studies published in English and those that used an acknowledged diagnostic criteria for TMD and headaches were included. Study quality was assessed using the Newcastle-Ottawa scale and meta-analyses were performed to generate pooled prevalence estimates.

Result: Thirty-one studies met the selection criteria for the review; 16 studies evaluated the prevalence of headache in TMD patients and 15 studies evaluated the prevalence of TMD in headache patients. The included studies were of moderate-to-high quality. Meta-analyses revealed moderate-to-large heterogeneities across included studies. Pooled prevalence estimates from meta-analyses indicated similar rates of headaches in TMD patients and of TMD in headache patients (61.58%, 95% CI 45.26–76.66 and 59.42%, 95% CI 51.93–66.60, respectively). Migraines were more commonly observed in TMD patients (40.25%, 95% CI 35.37–45.23) compared to tension-type headaches (18.89%, 95% CI 12.36–26.44). The prevalence of headaches was particularly high in painful-TMD (82.80%, 95% CI 75.41–89.10).

Conclusion: Despite large variance in prevalence rates across included studies, this review suggests headache and TMD frequently co-occur, particularly in the case of migraines and muscle related TMD. This association has important clinical, pathophysiological and therapeutic implications.

Keywords

headache, meta-analysis, migraine, prevalence, systematic review, temporomandibular disorder, tension-type headache

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Introduction

Temporomandibular disorder (TMD) is defined as a musculoskeletal disorder that affects the temporomandibular joint and/or masticatory muscles and related structures.[1] These conditions may present with pain in the TMJ and associated anatomical structures. The types of disorders this term includes is discussed later on, but it importantly excludes: non-painful conditions, TMJ pathology which may be congenital as well as traumatic and neoplastic TMJ conditions. TMD is also the most common painful chronic condition of non-dental origin pain in the head and neck region.[2] This condition often results in persistent pain, mandibular functional movement limitations and joint noises.[1] The prevalence of TMD varies between 31% in adults and 11% in adolescents. From the literature, disc displacement with reduction appears to be the most common condition among all TMD types.[3] TMD affects more women (15–26%) than men (8–15%),[4,5] occurs most often between the ages of 20 and 50 and commonly peaks in the fourth decade.[6–9] According to the diagnostic criteria of the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD)[10] and the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD),[11] TMD is categorised into the three groups: arthrogenous TMD (including disc disfunction and joint), myogenous TMD (masticatory muscle disorders), and headache attributed to TMD (Table 1). There are also other TMD diagnostic classifications by the American Association of Orofacial Pain (AAOP),[1] International Association for the Study of Pain (IASP)[12] and International Classification of Orofacial Pain (ICOP).[13] The IASP classification system covers several pain conditions and syndromes. TMD was included in the group of chronic headache and orofacial pain; it has very limited information regarding diagnosis of TMD.[14] The DC/TMD focused on the most common TMD classifications and provided a comprehensive assessment and validated value for each categorisation. The AAOP has now adopted the expanded DC/TMD taxonomy that includes validated diagnostic criteria for the most common TMDs as well as evidence-based criteria for less common TMDs. Recently, the International Headache Society (IHS) has developed the ICOP incorporating the DC/TMD diagnosis and pain taxonomy created by the IASP and also the International Classification of Diseases (ICD-11).[12] Although the ICOP adopts much of the terminology and criteria from DC/TMD, there are differences in terminology and in the distinction between primary and secondary pain.

Among headache disorders associated with TMD, primary headache disorders such as migraines and tension-type headache, especially in their chronic forms, constitute the most frequently comorbid conditions. Patients with TMD are twice more likely to exhibit a chronic daily headache pattern with or without a migraine biology and a linear relationship between the severity of TMD symptoms and the load of migraine symptoms has been postulated.[15] Additionally, the presence of headache modified by or secondary to TMD is recognised as headache attributed to TMD in the diagnostic criteria of DC/TMD[11] and ICHD-III.[16] The DC/TMD defines headache attributed to TMD as a headache in the temple area secondary to TMD pain modified by jaw movement, function, or parafunction, and familiar headache occurs with provocation testing by the examiner.[11] Contrarily, the ICHD-III criteria did not mention the location of a headache in the temple area. Moreover, they suggested evaluating the temporal relationship, which means that the headache developed after the onset of TMD.[16]

The relationship between primary headaches and TMD seems to be bidirectional, suggesting that the presence of the former condition increases the likelihood of experiencing the latter condition and vice versa.[17] Several elements may explain this relationship including gender similarities, peripheral sensitisation of anatomically shared structures, namely the trigemino-vascular system and central sensitisation of central nociceptive neuronal pathways, which may be shared in these conditions.[18,19] However, several aspects of the association between TMD and headache disorders remain unknown. Understanding the epidemiological aspects of this association is pivotal to correctly

Table 1. Classification of TMD subtype.

TMD subtypes	TMD classification (ICOP)[a]
Myogenous	Myofascial orofacial pain – Primary myofascial orofacial pain • Acute primary myofascial orofacial pain • Chronic primary myofascial orofacial pain – Secondary myofascial orofacial pain • Myofascial orofacial pain attributed to tendonitis • Myofascial orofacial pain attributed to myositis • Myofascial orofacial pain attributed to muscle spasm
Arthrogenous	Temporomandibular joint (TMJ) pain – Primary TMJ pain • Acute primary TMJ pain • Chronic primary TMJ pain – Secondary TMJ pain • TMJ pain attributed to arthritis • TMJ pain attributed to disc displacement • TMJ pain attributed to degenerative joint disease • TMJ pain attributed to subluxation
Headache attributed to TMD	Headache attributed to TMD (ICHD-III)[b]

TMD: temporomandibular joint disorder.
[a]International Classification of Orofacial Pain, 1st edition.
[b]The International Classification of Headache Disorders, 3rd edition.

diagnosing and managing patients with these conditions. To date there are no systematic reviews and meta-analysis solely investigating the prevalence of co-occurring TMD and headache. Our aim is to systematically review the prevalence of this association by reviewing the published literature and perform a meta-analysis.

Methods

The search strategy and protocol were registered and available in the PROSPERO database.[20] Data was collected and a meta-analysis was then performed. This systematic review was conducted and reported according to the PICO model and PRISMA guidelines.[21]

Search strategy

The following electronic bibliographic databases were searched: PubMed, CINAHL, Web of Science, MEDLINE, PsycINFO, Scopus, Embase and EBM Review Cochrane (published until April 2020). An additional literature search using Google Scholar, OpenGrey and reference lists of downloaded articles was also carried out. We used the following search terms for TMD: temporomandibular disorder, jaw joint pain, orofacial pain, facial pain, myofascial, aching jaw, mandibular dysfunction, masticatory system disorder, oro-mandibular disorder and combined with 'AND', followed by headache terms: headache, head pain and migraine. The search was conducted during April–May 2020.

Eligibility

All articles were accessible, published in English language and there were no time limitations. Observational study designs included prospective studies, case control studies, as well as cohort and cross-study designs. The review included studies with no participants of all ages, genders, and no other excluding factors. In order to be included in the review, the following criteria must have been used to diagnose TMD: Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD), Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), The American Academy of Orofacial Pain (AAOP) and headache diagnosis: The International Classification of Headache Disorders (ICHD) or The International Headache Society (IHS).

Data extraction and analysis

The studies were selected on the basis of the previously mentioned criteria and presence of the proportion of TMD patients with comorbid headache or vice versa. Additionally, association measurement between TMD group and headache group (odd ratio, risk ratio, prevalence ratio) was also collected. One reviewer screened articles initially, and two more reviewers assessed full articles and retrieved data. Any disagreements between reviewers were discussed until a conclusion was reached. The following information was extracted from the included studies:

- author and year of publication
- study design
- sample size and source of the sample
- location of study
- sample demographics
- method of diagnosis of TMD and other pain conditions
- outcomes

A meta-analysis was conducted by pooling prevalence rates from relevant studies. The articles pooled for meta-analysis diagnosed headache and TMD according to defined or standardise criteria such as the ICHD for headache and RDC/TMD or AAOP for TMD. The included studies diagnosed TMD by using structural questionnaires and/or clinical assessments. Fixed and random effects meta-analyses were conducted using Freeman-Tukey transformations to calculate weighted summary proportions.[22] Prevalence estimates were presented with 95% confidence intervals and Cochrans' Q and I2 statistics calculated to indicate the presence of heterogeneity. Random effects modelling was employed to allow for the high heterogeneity values from the variance of included studies ($I2 > 50\%$).[23] Forest plots were produced for all estimates. Analyses were conducted using SPSS (version 26.0, IBM) and MedCalc (MedCalc® Statistical Software).

Study quality

Rating for study quality was assessed by using The Newcastle-Ottawa Scale.[24] The checklist for quality criteria is shown in Table 2. The scoring of all criteria is based on the Newcastle-Ottawa guidelines. We adjusted the measure of sample size by rating one star if the number of participants was greater than or equal to 100 per group, which we considered an appropriate number of representative samples. In the case of difficulties or disagreements, reviewers discussed and reached a consensus.

Results

Search result and data collection

The results from the database searches are shown in Figure 1. Initially, all titles and abstracts were screened. Articles were assessed according to the eligibility criteria and their relevance to the review question. We reported two major groups of studies: headache prevalence in TMD patients (total studies = 16) and TMD prevalence in headache patients (total studies = 15). Tables 3 and 4 describe the characteristics and results of relevant investigations in headache prevalence found in TMD groups, while Tables 5 and 6 demonstrate TMD prevalence among headache

Table 2. Guideline for the Newcastle-Ottawa quality assessment scale regarding star awarding to assess quality and bias of studies (out of a total of nine stars).

	Star awarded criteria		
	Case-control study	Cross-sectional study	Cohort study
Selection	Independent validation for cases (*)	Representative of the average in the target population and sampling method described (*)	Representative of the exposed cohort in the community (*)
	Obviously representative series of cases (*)	Sample size $\geq$ 100 (*)	Non-exposed cohort selected from the same community as the exposed cohort (*)
	Community controls (*)	Non-respondents described and same rate for both groups (*)	Assessment blinded to case/control status and/or secure record (*)
	No history of disease for controls (*)	Validated measurement tool (**) Non-validated but described (*)	No outcome of interest at start of study (*)
Compatibility	Study controls for most important factor (*), for any additional factor (*)	Study controls for most important factor (*), for any additional factor (*)	Study controls for most important factor (*), for any additional factor (*)
Outcome	Assessment blinded to case/control status and/or secure record (*)	a) Independent blind assessment (**) b) Record linkage (**) c) Self-report (*)	a) Independent blind assessment (**) b) Record linkage (**) c) Self-report (*)
	Same method of ascertainment for cases and controls (*)	Clearly described and appropriate, association is presented, including confidence intervals and the probability level (*p* value) (*)	Follow-up long enough for outcome evaluation (*)
	Non-respondents described and same rate for both groups (*)		Complete follow up for all subjects (*)

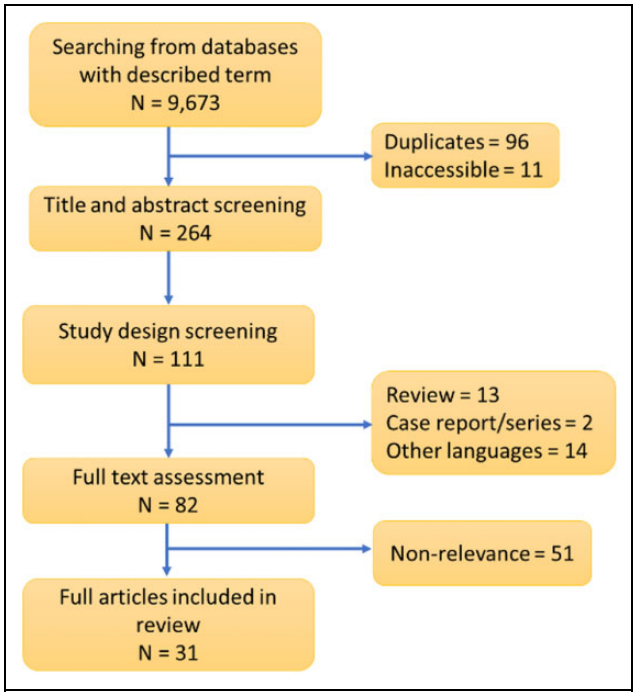

Figure 1. Search result diagram.

patients. The estimated prevalence with confidence intervals for each analytic approach are shown in meta-analysis forest plots (Figures 2 to 10). Quality and risk of bias assessment of include studies is scored and shown in Tables 7 and 8. All published articles achieved equal to or greater than five stars (out of nine stars), representing moderate-to-high quality of the studies in this review.

Meta-analysis results

Throughout the data extraction process, reviewers found few studies that employed the exact same diagnostic criteria and type of assessment. For example, only two studies[26,27] used the RDC/TMD criteria for clinical TMD diagnosis and questionnaires based on ICHD-II classification for headache. As such, to enable pooling of prevalence data via meta-analytic techniques, we combined findings from those studies that used structural questionnaires or interviews as well as those employing clinical evaluations with clarified or standardised diagnostic criteria.

Prevalence of primary headache in TMD patients. The estimated prevalence of primary headache disorders and their subtypes in the TMD population is presented in Figures 2 to 10. After pooling data from six studies, the overall prevalence of headache in the TMD population was 61.58% (95% CI 45.26–76.66) (Figure 2) and considerable heterogeneity was found among these studies ($I^2 = 98.62\%$, 95% CI 98.04–99.03). We additionally investigated the prevalence of two primary headache subtypes and found that 40.25% (95% CI 35.37–45.23) and 18.89% (95% CI 12.36–26.44) of TMD patients suffered from migraine and tension-type headache TTH, respectively (Figures 4 and 6).

Table 3. Characteristics of included studies on prevalence of headache in TMD patients ($N = 16$).

Study design		Author, year	Location	Sample size	Source of the sample	Gender	Mean age (years), ±SD
Case-control study	1	Kemper and Okeson, 1983[25]	USA	141 TMD patients	TMJ clinic	127 women,14 men	33
				159 controls	Patients sought for routine dental treatment	93 women, 66 men	27
	2	Franco et al., 2010[26]	Brazil	152 TMD patients	Orofacial pain clinic	84.2% women, 15.8% men	Women = 40.1, men = 41.7
				68 controls	Patients sought routine dental care	76.5% women, 23.5% men	Women = 38, men = 36.8
	3	Gonçalves et al., 2011[27]	Brazil	247 TMD patients	Orofacial pain clinic	82.7% women, 17.3% men	Women = 37.4, men = 39.8
				53 controls	Patients sought dental treatment		
	4	Hoffmann et al., 2011[28]	USA	1511 TMD patients	Web-based registry of the TMJ association	90% female	41
				57 controls	Unaffected TMD patients' friends	4:1 matched based on age, sex and education	
	5	Nilsson et al., 2013[29]	Sweden	285 TMD patients	33 public dental clinics	77.2% girls, 22.8% boys	16.0 ± 2.1
				302 controls		77.5% girls, 22.5% boys	16.1 ± 2.1
	6	Fernandes et al., 2019[30]	Brazil	149 TMD patients Case: 83 Painful TMD Control: 66 Non-painful TMD	Community adolescents	57% girls, 43% boys	13.7 ± 0.7
Cross-sectional study	7	Ciancaglini and Radaelli, 2001[5]	Italy	483 (at least one TMD symptom = 266)	Adult population	62.1% women, 37.9% men	44.9
	8	Mitrirattanakul and Merrill, 2006[31]	USA	246 Orofacial pain patients (TMD = 223)	University-based orofacial pain clinic	81.3% women	42.07 ± 0.95
				177 controls	General dental patients	49.9% women	42.07 ± 0.95
	9	Gonçalves et al., 2010[32]	Brazil	1230 (at least one TMD symptom = 430)	General population	51.5% women, 48.5% men	51% were in the 20–45
	10	Porporatti et al., 2015[33]	Brazil	400 TMD patients divided into four groups I) 64, II) 48, III) 173, IV) 115	1200 ical records	I.81.25% women II.89.58% women III.86.12% women IV.94.78% women	I.36.87 II.36.79 III.36.36 IV.36.79
Cross-sectional study	11	Dahan et al., 2016[34]	Canada	180 TMD patients Myofascial TMD = 121 Non-myofascial TMD = 59	TMD patients in two different hospitals	82.8% women	42.8 ± 1.2
	12	Contreras et al., 2018[35]	Brazil	352; 305 TMD patients, 47 healthy controls	Patients sought for dental care	83.8% women	37.7 ± 12.7
	13	de Melo Júnior et al., 2019[36]	Brazil	1342 (TMD = 445)	165 public schools	68.7% women, 31.3% men	Range 10–17
	14	Ashraf et al., 2019[37]	Finland	5876: migrainers = 498, nonmigrainers = 5378	Data taken from the nationwide health survey	Migrainers: 77.9% women, 22.1% man Non-migrainers: 51.6% women, 48.4% man	52.5 ± 14.8
	15	Wieckiewicz et al., 2020[38]	Poland	213 (painful TMD = 119, TMJ disorder = 104)	Inhabitants from four cities	149 women, 64 men	37 ± 15.84
Cohort	16	Di Paolo et al., 2017[39]	Italy	929 TMD patients	TMD clinic	Not provided	25.3% were in the 26–40

Table 4. Outcome summary of included studies on prevalence of headache in TMD patients ($N = 16$).

	Author, year	TMD diagnosis	Headache diagnosis	Main outcome (prevalence of headache)	Additional outcome
1	Kemper and Okeson,1983[25]	Questionnaire with described criteria	Self-report headache	TMD group: 68.1%, Control: 30.2% ($p = 0.001$) (at least one headache per week)	
2	Franco et al., 2010[26]	Symptom questionnaire and clinical examination guided by RDC TMD	Questionnaire based on ICHD-II	TMD group: 85.53%, Control: 45.58% ($p = 0.000$) prevalence of TMD in headache subtype, migraine: 55.26% tension-type headache: 30.26%	TMD samples reported higher risk for any headache (OR = 7.05; 95% CI 3.65–13.61), for migraine (OR = 2.76; 95% CI 1.50–5.06) and for tension-type headache (OR = 2.51; 95% CI 1.18–5.35)
3	Gonçalves et al., 2011[27]	Questionnaire and clinical assessment aligned with RDC/TMD	Questionnaire based on ICHD-II	TMD group: 95.14% Control: 54.72% ($p = 0.000$) Prevalence of TMD in headache subtype, chronic daily headaches (CDH): 35.22%, migraine: 35.22%, and episodic tension-type headache (ETTH): 14.98%	Individuals with myofascial TMD were significantly more likely to have CDH (RR = 7.8; 95% CI 3.1–19.6), migraine (RR = 4.4; 95% CI 1.7–11.7), and ETTH (RR = 4.4; 95% CI 1.5–12.6)
4	Hoffmann et al., 2011[28]	Self-reported TMD symptoms	Self-reported headache diagnosis	No overall prevalence of primary headache provided Migraine: TMD group 50%, controls 16% ($p < 0.001$) Tension-type headache (TTH): TMD group 64%, controls 23% ($p < 0.001$)	Before TMD existing, 20% of TMD samples reported migraine and 28% presented TTH. After TMD onset, the prevalence of migraine and TTH raised to 54% and 72% respectively
5	Nilsson et al., 2013[29]	2 questions for the presence of jaw pain	2 questions measured headache frequency and intensity	TMD group: 69.5%, Control: 26.2% ($p < .001$) (at least one headache per week)	Samples with headache $\geq$ once a week likely to have TMD pain, OR = 5.06 (95% CI 3.36–7.63, $p < 0.001$) than who have headache < once a week
6	Fernandes et al., 2019[30]	Questionnaire and clinical assessment based on RDC/TMD	Questionnaire used in the American migraine prevalence and prevention studies	Overall prevalence of primary headache was 79.87% Migraine: painful TMD 46.99%, non-painful TMD 22.72%, Tension-type headache (TTH): painful TMD 14.77%, non-painful TMD 16.87%	Painful TMD group was likely to have migraine (OR = 3.0; 95% CI 1.47–6.19, $p = .002$), probable TTH (OR = 0.7; 95% CI 0.33–1.42, $p = .307$), TTH (OR = 0.9; 95% CI 0.39–2.14, $p = 0.834$)
7	Ciancaglini and Radaelli, 2001[5]	Questions adapted from Agerberg and Helkimo	Self-report presence of headache	Individuals with TMD symptom: 27.44% control: 15.20% ($p = 0.002$)	Significant correlation between headache with TMD symptom with OR = 2.11; 95% CI 1.30–3.42, $p = 0.002$
8	Mitrirattanakul and Merrill, 2006[31]	Clinician diagnosis by using AAOP	Clinician diagnosis guided by ICHD-II	31.66% individuals with TMD had primary headache 66.67% headache patients had TMD	Risk of having headache in patients with TMD, OR = 1.51 (95% CI 1.28–2.24), $p = .004$. Risk for having TMD in patients with headache, OR = 3.00 (95% CI 0.869–10.36), $p = 0.82$

(continued)

Table 4. (continued)

	Author, year	TMD diagnosis	Headache diagnosis	Main outcome (prevalence of headache)	Additional outcome
9	Gonçalves et al., 2010[32]	Questionnaire adapted from AAOP proposal	Questionnaire based on ICHD-II	Individuals with TMD symptom: 56.51% control: 31.89% ($p = 0.002$) prevalence of TMD in headache subtype, migraine 32.33% episodic tension-type headache (ETTH)]: 19.10% chronic daily headaches (CDH): 5.12%	compared with samples without headache, TMD pain was increased in migraine (PR = 5.3; 95% CI 3.8–7.4), CDH (PR = 3.9; 95% CI 1.8–8.1) and ETTH (PR = 2.7; 95% CI 1.8–3.9)
10	Porporatti et al., 2015[33]	Previous clinician diagnosis based on AAOP	Previous clinician diagnosis based on IHS	40.75 % of TMD patients had comorbid primary headache	
11	Dahan et al., 2016[34]	Questionnaire and clinical screening guided by RDC/TMD	ID-Migraine Questionnaire	All TMD groups reported migraine: 46.11% myofascial TMD reported migraine: 54.55% non-myofascial TMD reported migraine: 28.81%	Self-reported migraine patients were likely to have myofascial TMD three times than non-myofascial TMD, OR = 3.00 (95% CI 1.14–6.40)
12	Contreras et al., 2018[35]	The Fonesca Aamnestic Index	Questionnaire and physical assessment using ICHD-II	86.55% of patients with painful TMD presented comorbid migraine	
13	de Melo Júnior et al., 2019[36]	Questionnaire and clinical examination based on RDC/TMD	Question No.18 of the RDC/TMD Axis II	TMD group: 77.98 % controls: 67.44%	
14	Ashraf et al., 2019[37]	Examination guidelines by Dworkin and LeResche	Prior diagnosis by a physician	Overall TMD patients reported 14.58% of migraine, controls 7.98%. Muscular disorder in migrainous patients was 81.25%	Painful muscular TMD, but not joint related TMD was associated with the presence of migraine (OR = 1.5; 95% CI 1.23–2.04, $p < 0.01$)
15	Wieckiewicz et al., 2020[38]	Clinical evaluation using DC/TMD	Self-identity questionnaire guided by Head-Hunt Study and ICHD-III	Pain-related TMD group: overall headache 58.82%, migraine 31.93%, tension-type headache 26,89%. TMJ disorder group: overall headache 47.11%, migraine 26.92%, tension-type headache 20.19%	Patients suffering from TMD-related pain were likely to have any headache, (OR = 4.77, 95% CI 2.44–9.32, $p = .000$) For migraine (OR = 4.53, 95% CI 2.06–5.95, $p = .000$), for tension-type headache (OR = 2.80, 95% CI 1.31–5.97, $p = .005$)
16	Di Paolo et al., 2017[39]	Previous clinician diagnosis based on DC/TMD	Clinical examination based on ICDH-III	Overall headache 67.28% Migraine: 40.26% tension-type headache: 22.28%	

Table 5. Characteristics of included studies on prevalence of TMD in headache patients ($N = 15$).

Study design		Author, year	Location	Sample size	Source of the sample	Gender	Mean age (years), ±SD
Case-control study	1	Liljeström et al., 2001[40]	Finland	296: Headache group = 230, Controls = 66	Primary school children	49.15% girls, 50.85% boys	13.4
	2	Liljeström et al., 2005[41]	Finland	296: Headache group = 231, Controls = 65	Children in primary school	48.99% girls, 51.01% boys	13.4
	3	Glaros et al., 2007[42]	USA	Headache group = 23	General population	96% women, 4% men	38.77 (9.26)
				Control = 17		76% women, 24% men	32.51 (10.42)
	4	Stuginski-Barbosa et al., 2010[43]	Brazil	episodic migraine (EM) = 31 chronic migraine (CM) = 34	Patients in headache clinic	EM: 68.8% women CM: 75.6% women	32.7
				controls without migraine = 28		82.2% women	33.6
	5	Gonçalves et al., 2013[44]	Brazil	episodic migraine (EP) = 38 chronic migraine (CM) = 23	University-based headache clinic	100% women	EM = 39.16 CM = 38.83
				controls without headache = 30			38.83
	6	Franco et al., 2014[45]	Brazil	1307: Headache = 595 No headache = 712	Children from public school	56.8% girls, 43.2% boys	range 12–14
	7	Wagner and Filho, 2018[46]	Brazil	160; frequent episodic tension-type headache (FETTH) group = 80	Military firefighters sought treatment at the orofacial pain clinic	48 women, 32 men	38.5
				control group = 8		36 women 44 men	35.2
Cross-sectional study	8	Reik and Hale, 1981[47]	USA	100 (reported only 11 patients with unilateral TMD)	Headache patients in the headache Clinic	9 women, 2 men	median = 32
	9	Wänman and Agerberg, 1986[48]	Sweden	285 children	General participants in the urban districts	48.8% girls, 51.2% boys	17
	10	Ballegaard et al., 2008[4]	Denmark	98 Headache patients	Patients in headache centre	76 women, 23 men	44.8
	11	Gonçalves et al., 2009[15]	Brazil	1,230	General populations	51.5% women, 48.5% men	51% were in 20–45
	12	Tomaz-Morais et al., 2015[49]	Brazil	42 Headache patients	Patients from neurology clinic	40.5% women 59.5% men	31
Cross-sectional study	13	Florencio et al., 2017[50]	Brazil	84 samples: episodic migraine (EM) = 31, chronic migraine (CM) = 21, healthy women = 32	University-based hospital	All was women	EM = 33±11 CM = 35±10 controls = 31±9
	14	Sojka et al., 2018[51]	Poland	40	Neurology Department	19 women, 21 men	14.9
	15	Mingels et al., 2019[59]	Belgium	44: episodic cervicogenic headache (CeH) = 22, control = 22	General call launched inside university	100% women	episodic CeH = 20.7 ± 2.5 controls = 21± 2.3

Table 6. Outcome summary of included studies on prevalence of TMD in headache patients ($N = 15$).

	Author, year	TMD diagnosis	Headache diagnosis	Main outcome (prevalence of TMD)	Additional outcome
1	Liljeström et al., 2001[40]	Questionnaire and clinical examination with described criteria	Clinical assessment using IHS 1998	Headache group: 67.83% presented very mild–moderate sign of TMD Controls: 56.06% presented very mild–moderate sign of TMD	
2	Liljeström et al., 2005[41]	Interview and clinical examination with described criteria	Clinical assessment using IHS 1998	Headache group: 79.65% reported TMD pain Control group: 72.31% reported TMD pain	Comparing to controls, children with migraine had more signs of TMD with COR = 2.1; 95% CI 1.1–4.2 and migraine-type headache group presented COR = 2.2; 95% CI 1.1–4.2
3	Glaros et al., 2007[42]	Clinical assessment using RDC/TMD	Questionnaire based on ICHD-II	Headache group: 47.83% met myofascial pain diagnosis, 78.26% had arthralgia. Controls: none of controls ($N = 17$) reported TMD	
4	Stuginski-Barbosa et al., 2010[43]	Clinical evaluation described by Helkimo	Clinical examination based on ICHD-II	83.87% of EM and 94.28% of CM presented at least 1 TMD sign. The significant difference was found in CM relative to controls ($p < 0.05$) 71.42% of controls reported TMD sign	Participants with EM are likely to have tenderness in the masticatory muscles with OR = 3.0; 95% CI 1.1–8.9), CM had OR = 6.9; 95% CI 2.3–21.2 For tenderness in the TMJ, EM reported OR = 4.7; 95% CI 1.5–14.5), CM had OR = 4.8; 95% CI 1.6–14.5
5	Gonçalves et al., 2013[44]	Physical assessment guided by RDC/TMD	Physical assessment guided by ICHD-II	Overall (EM+CM): TMD presented 88.52% Episodic migraine (EM) 86.8%, chronic migraine (CM) = 91.3%, control group = 33.3%, prevalence was significant between CM and EM ($p < 0.001$)	Risk for TMD, EP had OR = 3.15; 95% CI 1.73–5.71 and CM showed OR = 3.97; 95% CI 1.76–8.94
6	Franco et al., 2014[45]	Clinical examination based on RDC/TMD	Question No. 18 of the RDC/TMD Axis II history questionnaire	Headache in TMD group: overall TMD 66.25%, painful-TMD 73.94%, non-painful TMD 28.36%. TMD in headache group: overall headache 44.20%, painful TMD 41.01%, non-painful TMD 3.19%. 18.82% of controls without headache had those both types of TMD	Children with headache had higher risk for painful TMD with OR = 4.94; 95% CI 3.73–6.54, $p < 0.001$
7	Wagner and Filho, 2018[46]	Physical examination based on RDC/TMD	Physical examination based on ICHD-II	FETTH group: 76.25%, controls: 11.25 %	the association between painful TMD and FETTH (OR = 26.4; 95% CI 10.4–64.6; $p < 0.001$)
8	Reik and Hale, 1981[47]	Clinical examination with informed criteria	Clinical examination guided by the Ad Hoc Committee on Classification of Headache	14% Patients with unilateral headache presented comorbid TMJ pain dysfunction	

(continued)

Table 6. (continued)

	Author, year	TMD diagnosis	Headache diagnosis	Main outcome (prevalence of TMD)	Additional outcome
9	Wänman and Agerberg, 1986[48]	Questionnaire and clinical examination with explained criteria	Questionnaire and clinical examination with explained criteria	72.7% of participants with headache reported painful masticatory muscle on palpation	
10	Ballegaard et al., 2008[4]	Clinical examination using RDC/TMD	Clinical examination using ICHD-II	56.12% of overall headache patients met TMD diagnosis Prevalence of TMD in subgroup of headache: migraine with and without aura (MIG) = 53.3%, tension-type headache (TTH) = 45.4%, MIG+TTH 75% and MIG+TTH+medication overuse headache = 50%	
11	Gonçalves et al., 2009[15]	Symptom questionnaire based on AAOP	Questionnaire used in research in Brazil	51.48% of headache patients and 27.66% of controls reported at least one symptom of TMD Prevalence of TMD in subgroup of headache: episodic tension-type headache = 41%, migraine = 58.2%, chronic daily headache = 66.7%	Prevalent ratio (PR) of TMD symptoms in episodic tension-type headache was 1.48; 95% CI 1.20–1.79, migraine PR = 2.10; 95% CI 1.80–2.47, and chronic daily headache PR = 2.41; 95% CI 1.84–3.17
12	Tomaz-Morais et al., 2015[49]	Fonseca's questionnaire	Previous clinician diagnosis based on ICHD-II	TMD in overall headache 54.76 % Prevalence in subgroup: migraine 71.34%, TTH 38.10%	
13	Florencio et al., 2017[50]	The Fonesca Anamnestic Index questionnaire	Physical assessment ICHD-III	TMD sign and symptom was 78% for episodic migraine (EM), 100% for chronic migraine (CM) and 54% for control group	EM were more likely to have TMD with RR = 1.77; 95% CI 1.14–2.73 ($p = 0.01$) and for CM, RR = 2.28; 95% CI 1.54–3.39 ($p < .001$)
14	Sojka et al., 2018[51]	Clinical evaluation based on RDC/TMD	Clinical diagnosis based on ICHD-II	Overall, 72.50% of headache patients had TMD. 40% suffered from muscle disorders, 32.5% had disc displacement with reduction	
15	Mingels et al., 2019[52]	Preclinical signs of TMD; Temporo-mandibular range of motion and Temporo-mandibular palpation pain	Interview questions based on ICHD-III	Headache patients reported pain on palpation at 10/44 sites of lateral TMJ (right and left from 22 samples) and 61/66 sites of masseter muscle Control group presented pain on palpation at 6/44 sites of lateral TMJ (right and left from 22 samples) and 13/66 sites of masseter muscle	Headache group showed smaller maximal mouth opening ($p < 0.05$) and had more positive pain responses of the masseter at the origin, body and insertion

Table 7. Quality assessment of studies using Newcastle-Ottawa scale* for assessing included studies on prevalence of headache in TMD patients.

Reference study	Selection				Compatibility	Outcome			
Case-control study	Adequate case definition (*)	Representativeness of the cases (*)	Selection of Controls (*)	Definition of Controls (*)	Comparability of cases and controls (**)	Ascertainment of exposure (*)	Same method of ascertainment (*)	Non-Response rate (*)	Total (9*)
Kemper and Okeson,1983[25]	*	*		*		*	*		5
Franco et al., 2010[26]	*	*		*	*	*	*	*	7
Gonçalves et al., 2011[27]	*	*		*	**	*	*		7
Hoffmann et al., 2011[28]		*		*	**	*	*		6
Nilsson et al., 2013[29]		*		*	**		*	*	6
Fernandes et al., 2019[30]	*	*	*	*	**	*	*		8
Cross-sectional study	Representativeness of the sample (*)	Sample size (*)	Non-respondents (*)	Validated measurement tool (**)	comparable subjects, controlled confounding (*)	Assessment of outcome (**)	Appropriate statistics used (*)		Total (9*)
Ciancaglini and Radaelli, 2001[5]	*	*		*	*	*	*		6
Mitrirattanakul and Merrill, 2006[31]	*	*		**	*	**	*		8
Gonçalves et al., 2010[32]	*	*	*	**	*		*		7
Porporatti et al., 2015[33]	*	*	*	**	*	*			7
Dahan et al., 2016[34]	*	*	*	**	*	*	*		8
Contreras et al., 2018[35]	*	*	*	**	*	*	*		8
de Melo Júnior et al., 2019[36]	*	*		*	*	*	*		6
Ashraf et al., 2019[37]	*	*	*	*	*	*	*		7
Wieckiewicz et al., 2020[38]	*	*		**	*	*	*		7
Cohort study	Representativeness of the exposed cohort (*)	Selection of the non-exposed cohort (*)	Ascertainment of exposure (*)	no outcome of interest was presented (*)	Comparability of the design, analysis (**)	Assessment of outcome (*)	follow-up long enough (*)	Adequacy of follow up of cohorts (*)	Total (9*)
Di Paolo et al., 2017[39]	*	*	*	*	**	*		*	8

*Guideline for star allocation shown in Table 2.

Table 8. Quality assessment of studies using Newcastle-Ottawa scale for assessing included studies on prevalence of TMD in headache patients.

Reference study	Selection				Compatibility	Outcome			Total (9*)
Case-control study	Adequate case definition (*)	Representativeness of the cases (*)	Selection of Controls (*)	Definition of Controls (*)	Comparability of the design, analysis (**)	Ascertainment of exposure (*)	Same method of ascertainment (*)	Non-Response rate (*)	
Liljeström et al., 2001[40]	*	*	*	*	*	*	*	*	8
Liljeström et al., 2005[41]	*	*	*	*	*	*	*	*	8
Glaros et al., 2007[42]	*		*	*	*	*	*		6
Stuginski-Barbosa et al., 2010[43]	*			*	**	*	*	*	7
Gonçalves et al., 2013[44]	*			*	**	*	*		6
Franco et al., 2014[45]		*	*	*	**		*	*	7
Wagner and Filho, 2018[46]	*	*		*		*	*	*	6
Cross-sectional study	Representativeness of the sample (*)	Sample size (*)	Non-respondents (*)	Validated measurement tool (**)	comparable subjects, controlled confounding (*)	Assessment of outcome (**)	appropriate statistics used (*)		Total (9*)
Reik and Hale,1981[47]	*	*		*		*	*		5
Wänman and Agerberg, 1986[48]	*	*		*	*	**	*		7
Ballegaard et al., 2008[4]	*		*	**	*	**	*		8
Gonçalves et al., 2009[15]	*	*		**	*	*	*		7
Tomaz-Morais et al., 2015[49]	*		*	**	*	*			6
Florencio et al., 2017[50]	*		*	**	*	*	*		7
Sojka et al., 2018[51]	*		*	**		**	*		7
Mingels et al., 2019[52]	*	*	*	*	*	*	*		7

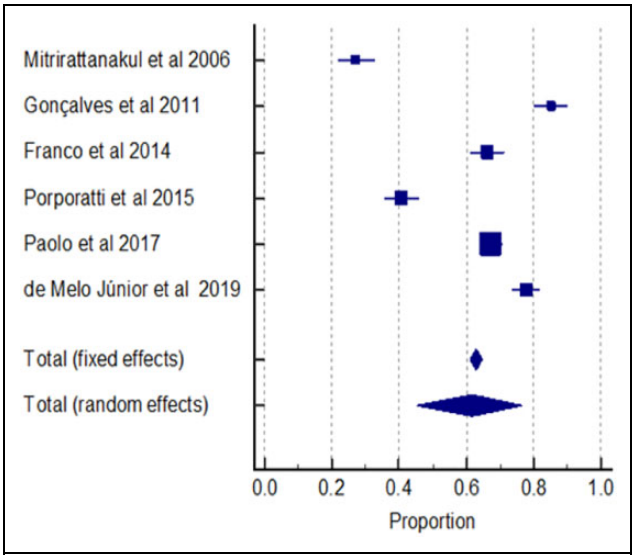

Figure 2. Forest plot of prevalence of headaches in TMD.

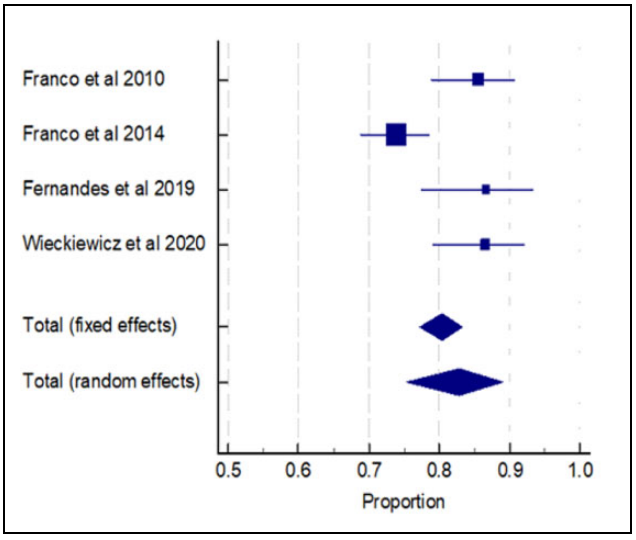

Figure 3. Forest plot of prevalence of headaches in painful-TMD.

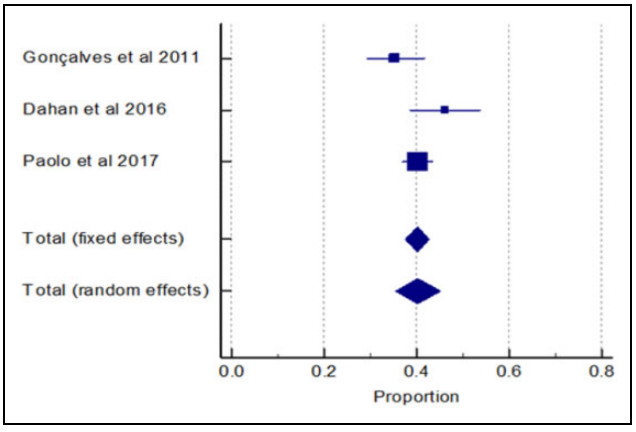

Figure 4. Forest plot of prevalence of migraine in TMD.

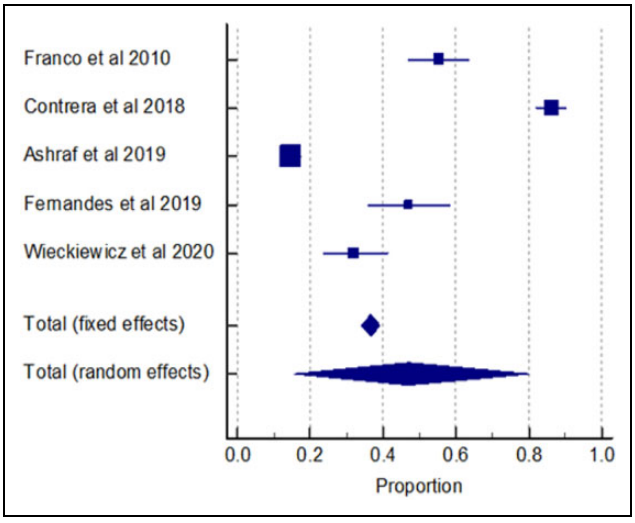

Figure 5. Forest plot of prevalence of migraine in painful-TMD.

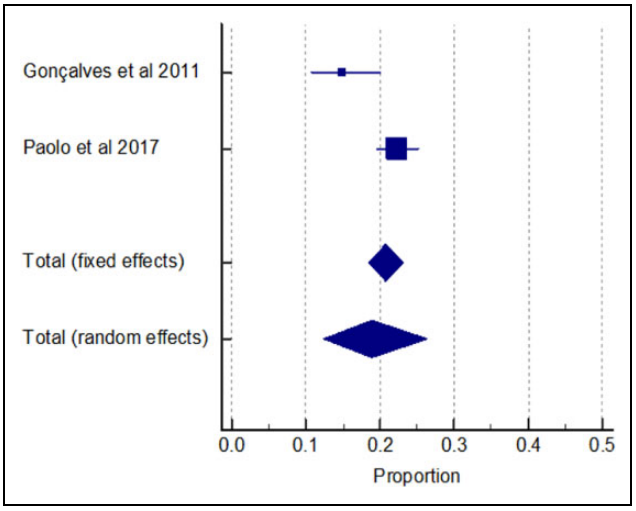

Figure 6. Forest plot of prevalence of tension-type headache in TMD.

The heterogeneity test for both analyses indicated moderate to high variability of included studies. Migraine prevalence in TMD resulted in $I^2 = 61.19\%$, 95% CI 0.00–88.94 and TTH prevalence analysis showed $I^2 = 85.10\%$, 95% CI 39.53–96.33.

Further analysis focusing on the painful-TMD group only revealed a prevalence estimate of headache of 82.80%, 95% CI 75.41–89.10 (Figure 3) with $I^2 = 80.95\%$, 95% CI 50.13–92.73. Regarding headache subtypes, 47.09% (95% CI 15.50–80.07) and 31.42% (95% CI 26.63–36.52) of painful TMD population experienced migraine and TTH, respectively (Figures 5 and 7). The measure of heterogeneity presented high inconsistency among pooled studies on migraine in TMD ($I^2 = 99.32\%$, 95% CI 99.08–99.50) and moderate inconsistency in pooled studies on TTH in TMD ($I^2 = 47.34$, 95% CI 0.00–84.57).

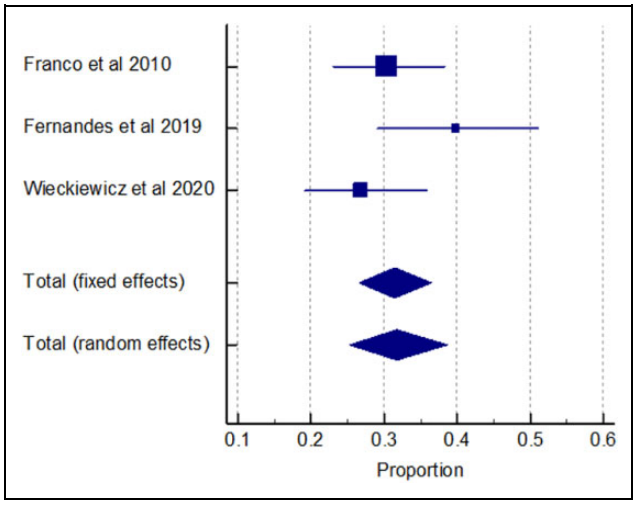

Figure 7. Forest plot of prevalence of tension-type headache in painful-TMD.

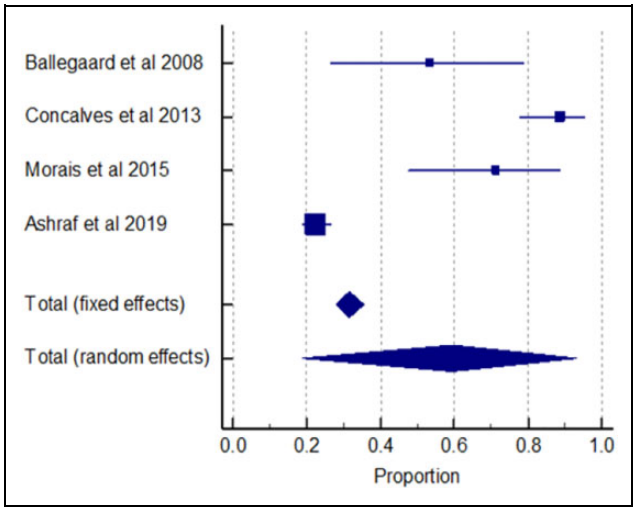

Figure 9. Forest plot of prevalence of TMD in migraine.

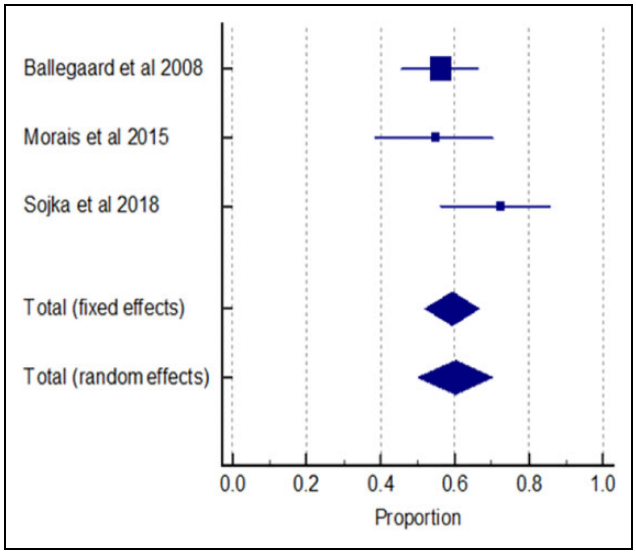

Figure 8. Forest plot of prevalence of TMD in headaches.

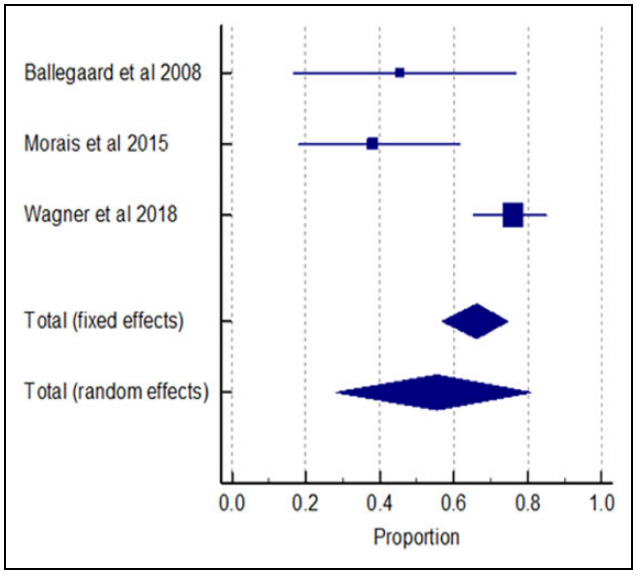

Figure 10. Forest plot of prevalence of TMD in tension-type headache.

Prevalence of TMD in headache patients. Four studies measuring TMD prevalence in headache patients were pooled using a meta-analytic approach. The proportion of TMD in all primary headache patients is presented in Figures 8 to 10. The result showed that 59.42% (95% CI 51.93–66.60) of the headache population had TMD (Figure 8) with a moderate I^2 value of 46.52%, 95% CI 0.00–84.26. In terms of the primary headache subgroup, 59.29% (95% CI 18.82–93.30) of migraine patients and 55.39% (95% CI 28.04–81.09) of TTH patients had TMD (Figures 9 and 10). There were high levels of heterogeneity for studies of TMD prevalence in migraine (I2 = 97.74% (95% CI 96.17–98.67)) and in the investigation of TMD prevalence in TTH (I2 = 84.24% (95% CI 52.88–94.73)).

Discussion

The present systematic review included 31 studies investigating the prevalence of primary headache among patients with TMDs and vice versa. TMD and headache diagnostic criteria differed across the studies because of the evolution of classification systems overtime. The diversity of diagnostic criteria, study designs, as well as population demographics contributed to a challenge in the meta-analytic approach and resulted in a high degree of heterogeneity among pooled studies.

Some of the included studies which used a clinical assessment of patients for headache and TMD[31,33] reported a lower prevalence of these conditions compared to those studies which only used a standalone questionnaire to

diagnose these conditions.[26,27] This might be because clinical examination is more validated than questionnaires and results in lower proportion of participants recruited in research. From the perspective of sample size and source, larger samples in population-based studies appeared to indicate a lower prevalence of disorders[28,32,37] compared with smaller studies performed in hospitals.[25,34,35] Even though such studies are more feasible in tertiary care or university-based hospitals, the higher prevalence estimates are often found in epidemiological research due to the higher rate of disease than in the general population.

Most studies in this review used standard and widely acceptable diagnostic guidelines, RDC/TMD, ICHD-II etc., but undertook different methods of assessment which included: self-reported questionnaires, face-to-face or telephone interviews, or formal physical examination. Participants of the included studies had non-specific occupations, were of middle-age and included both genders. However, one study only examined firefighters[46] and there were other studies which only examined young participants[29,30,36,41,45,48] or female adults.[44,50,52] Our review showed that epidemiological studies favoured investigating younger populations and the female population, which may be due to the high prevalence of TMD occurring in these two subgroups.[53] It has been suggested that women are almost two times more likely to suffer from headache compared to men which may account for these differences.[54]

Our review showed that the prevalence of headache in the TMD population was 61.58%. Gonçalves et al.[27] reported the highest headache frequencies at 85.42% while Mitrirattanakul and Merrill[31] obtained the lowest of that at 27.24%. Migraine is the most common headache subtype in all TMD patients with a prevalence of 40.25%, which is much higher than the prevalence of headaches in the general population and twice as high as the prevalence of tension-type headache (18.89%). Chronic daily headache (CHD) is an umbrella term, not a diagnosis, comprising of several primary and secondary headache disorders. Despite the lack of a sufficient number of studies in the literature, it seems that the prevalence of TMD in CHD ranged between 5.12% in one study[32] and 35.22% in another study,[27] while the prevalence of CHD in TMD was 66.7%.[15] This suggests that TMD is frequently associated with a daily headache disorder, often migraine and TTH and perhaps other chronic headache disorders, likely chronic migraine maybe associated with TMD.

We performed an additional subgroup analysis of painful and non-painful TMD. A very high prevalence of headache (82.80%) was seen in painful-TMD patients, with small variations between studies (from 73.94% to 86.75%).[30,45] Migraine remains the most common comorbid condition among these patients (47.08%) followed by tension-type headache (31.42%). After pooling studies on non-painful TMD, we found only one study based on the clear definition of non-painful TMD with the recognised assessment – DC/TMD.[38] This study only investigated non-painful TMD in TTH and migraine patients, reporting a proportion of headache in non-painful TMD patients of 78.85%, mostly migraine (31.93%), followed by TTH (20.19%).[38] The prevalence of headache in non-painful TMD is almost as high as the prevalence in painful TMD, with interesting pathophysiological implications that should be explored in future studies. The analysis of studies investigating the prevalence of headache in the subgroup of TMD suggested that migraine is particularly associated with painful muscular TMD, but not with joint-related pain.[37] Individuals with painful muscle-related TMD symptoms had a 1.6-fold higher risk of having migraine than those with other TMD symptoms. In addition, TMD pain, either muscular or joint-related origin, that presented with migraine was also associated with higher migraine frequency and higher prevalence of medication use headache.[37]

We also explored the prevalence of TMD in the headache population. Most studies investigating TMD in headache patients rarely classified TMD subgroups; instead, they differentiated by headache subtypes. The results showed that 59.42% of headache patients suffer from TMD, with variation in percentage between 54.76% and 72.50%.[49,51] Migraine patients are slightly more likely to have TMD in comorbidity compared to tension-type headache patient (respectively 59.29% and 55.39%). Although our meta-analysis didn't include TMD prevalence in non-headache population, it was evident that the prevalence of TMD was higher in patients with headache compared to people without headache; additionally, myogenous TMD patients were more likely to report headaches than those with arthrogenous TMD.[5] The relationship of myogenous TMD and headache was also consistent with Sojka et al.'s study,[51] who found headache patients suffered mostly from muscle dysfunction (40%) and 32.5% from disc displacement with reduction.

The prevalence of comorbid headache in TMD and concurrent TMD in headache from this review are quite similar (61.58% and 59.42%). Despite the large variance across included studies, the review therefore suggests a high co-occurrence of the two disorders in the general and clinical populations. Headache is mostly found in painful TMD sufferers and migraine appears to be most prevalent type of primary headache found among total TMD patients. Besides the main findings, results from measuring association of two conditions also showed significantly higher risk of having headache in TMD group compared to healthy controls.[6,26,29–32,38,55] However, some of the included studies were conducted in tertiary university-based hospital with small sample sizes. Further epidemiological studies should be performed in large population-based investigation. Other studies focusing on the relationship and mechanism or aetiologies between the two pathologies should also be conducted to provide better understanding and management in patients with both conditions.

The pathophysiology of TMD and headache involves the peripheral and central nervous systems. The trigeminal pathway is a key component in the nociceptive transmission and processing of TMD pain and headache.[10,18] Trigeminal nerve activation is therefore thought to play a significant role in the underlying mechanisms of headache and facial pain disorders, including TMD.[10,18,19] Peripheral and central sensitisation may contribute to the overlap of the two disorders and lead to the difficulties in distinguishing both conditions. Therefore, headache and TMD may occur as separate or overlapping entities. Although there is no evidence to date of a causal relationship between TMD and primary headaches, they may be related in a bidirectional fashion. TMD signs and symptoms may be a perpetuating factor for the primary headache and the primary headache may similarly act as a triggering pain for the TMD condition.[17] This could be a supporting explanation for Gonçalves et al.'s study,[56] which revealed the significant improvement in migraine when TMD was treated in patients with TMD comorbid with migraine.

This review showed a high prevalence of TMD and primary headache disorders in the same individual. This implies that an association between two conditions may exist. This finding highlights the importance routine TMJ evaluation in headache clinics as well as careful headache phenotyping in dental/maxillo-facial settings, to fully assess our patients' symptoms. When TMD and headache coexist, the management of both conditions may lead to a better outcome and patient satisfaction.

Limitation of the review

This systematic review analysed multiple study designs, including studies without control groups, but the difference in prevalence estimates between patient and control samples related to comorbid conditions were not assessed in the meta-analysis. In addition, only English-language articles were included in our systematic review. Without a language restriction, the review could capture more information and thus eliminate systematic bias. Another point to consider is that the data from this review were pooled across studies using different diagnostic criteria and methods. Therefore, a degree of caution in interpreting the findings is warranted. Although the prevalence estimates obtained show moderate to high heterogeneity, subgroup analyses are of little use when the number of studies included in the meta-analysis is too small to conduct meaningful subgroup analyses. Additionally, this review only estimated the prevalence of headaches associated with TMD. Importantly, chronic pain in localised areas, such as headache and TMD, which may occur concurrently, may be a feature of FMS. Clinicians should not ignore this and should investigate other areas of pain in the body besides headache or TMD pain.

Conclusions

The findings of this systematic review suggest that primary headache disorders are highly prevalent in TMD. Migraine and TTH are the most prevalent headache disorders associated with TMD and they often occur in their chronic subtype. Migraine is the most frequent headache condition associated with painful myogenous TMD. Similarly, a high proportion of patients with primary headache disorders suffers with TMD, though it is unclear which subtypes of TMD are more prevalent in headache patients. Migraine and TTH seem to be the headache conditions more often associated with TMD.

Large population-based studies using uniform diagnostic criteria are needed to clarify the details of the epidemiological association between TMD and headache. However, current available data highlights the importance of their association in terms of similar pathophysiological mechanisms, chronification mechanisms, and overlapping treatments. In light of this research need, future studies should shed light on the epidemiological, clinical, pathophysiological and treatment aspects of this association.

Article highlights

- Primary headache disorders are frequent in TMD and vice versa.
- Migraine and TTH appear to be the most common headache disorders associated with TMD.
- Migraine is the most prevalent headache condition associated with painful TMD.

Declaration of conflicting interests

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