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ORIGINAL ARTICLE

Mandibular asymmetry as a possible etiopathologic factor in temporomandibular disorder: a prospective cohort of 134 patients

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Abstract

Objectives The present study aimed to investigate mandibular asymmetry as a possible etiopathologic factor in temporomandibular disorder (TMD).

Materials and methods A prospective cross-sectional study of patients with dentofacial deformities seeking corrective orthognathic surgery was conducted. The pre-operative prevalence of TMD in patients with mandibular asymmetry and other dentofacial deformities was assessed using the Diagnostic Criteria for TMD (DC/TMD) Axis I protocol.

Results A total of 134 patients were recruited – 82 with mandibular asymmetry and 52 without. There was a significantly higher prevalence of TMD in those with mandibular asymmetry (67.1%; 95% CI 59 to 75%) compared to those without (40.4%; 95% CI 32 to 49%, $p = 0.002$). The overall pre-operative prevalence of TMD in this population of patients was 56.7% (95% CI 48 to 65%). Pain disorder only was present in 9.7%, TMJ disorder only in 29.9%, and both pain and TMJ disorders in 17.2%. The most prevalent type of TMD is disc displacement with reduction (77.6%), followed by myalgia (35.5%) and arthralgia (21.1%).

Conclusion The prevalence of TMD in those with mandibular asymmetry was significantly higher than those without, suggesting that mandibular asymmetry could be a possible etiopathologic factor in TMD.

Clinical relevance The significantly higher prevalence of temporomandibular disorder in those with mandibular asymmetry suggests that we need to be especially cognizant of this condition in our pre-operative, surgical, and post-operative management of this group of orthognathic patients.

Keywords Mandibular asymmetry · Temporomandibular disorder · Orthognathic surgery

Introduction

Dentofacial deformities have been associated with temporomandibular disorder (TMD) and pathology [1]. Adaptive developmental changes and post-developmental degenerative changes of the temporomandibular joints (TMJs) can alter the facial skeleton and occlusion. Vice versa, trauma or developmental deformity that causes changes in skeletal morphology and occlusion can alter the biomechanics of the TMJ, which consequently develops into TMJ internal derangement [2]. As a matter of fact, the chief complaints of many patients with facial asymmetry in our orthognathic unit are difficulty in mastication, esthetic dissatisfaction, and, unsurprisingly, frequent or recurrent jaw joint discomfort. Despite the plausible link of mandibular asymmetry and TMD, available epidemiological data on disease prevalence is lacking. Of note, facial asymmetry is highly prevalent among the Southern Chinese population with reported prevalence varying from 21 to over 40% [3, 4]. According to a local large-scale telephone survey, involving 1526 respondents by Pow et al. in 2001, 33% of the population was reported to be afflicted by jaw pain. This is higher than the reported prevalence of 5 to 12% of the population in the literature [5]. Moreover, it was reported that those having "TMD-related jaw pain that was of moderate or severe intensity and occurred frequently" constituted a notable 1% of the Hong Kong Chinese population [6]. This raises a possible correlation between the higher prevalence of facial asymmetry and higher reported TMD rates in the population, which has yet to be elucidated.

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Although there have been studies reporting on TMD prevalence rates in those with dentofacial deformities, most of these studies do not distinguish among the various types of dentofacial deformities or delve specifically into patients with mandibular asymmetry. There has yet to be a clinical study that investigates TMD primarily in those with mandibular asymmetry. Hence, the aim of this study was to investigate the pre-operative prevalence of TMD in orthognathic patients, in particular in those with mandibular asymmetry, to provide epidemiological evidence for mandibular asymmetry as a possible etiopathologic factor in TMD. We hypothesize that there is a higher prevalence of TMD in those with mandibular asymmetry as compared to those without.

Materials and methods

A prospective cross-sectional study of patients with dentofacial deformities seeking corrective orthognathic surgery at the Division of Oral and Maxillofacial Surgery, Faculty of Dentistry, the University of Hong Kong was conducted. Participants were recruited during the period from February 2019 to October 2019. Patients with mandibular condyle pathology such as osteochondroma, previous facial trauma, history of TMJ surgery, craniofacial syndromes, and systemic autoimmune or neuromuscular diseases were excluded. Ethics approval was obtained from the local institutional review board (HKU/HA HKW IRB UW 18-566). Written consent was obtained from participants before data collection.

Data collection

The demographic data (age and gender) of all recruited participants, their skeletal class (I, II, or III), the presence of mandibular asymmetry, the magnitude and direction of mandibular asymmetry if present, and the presence of TMD symptoms were recorded.

Measurement of mandibular asymmetry

The magnitude of mandibular asymmetry was determined clinically by measuring the distance between the mid-point of the chin and the facial midline (taken as the true vertical line between the inner canthi). This measurement was corroborated radiographically with a posteroanterior cephalometric tracing. Participants were categorized as having mandibular asymmetry if they had a chin point deviation of 2 mm or greater in the frontal plane.

Assessment of temporomandibular disorder

Assessment of TMD status was performed according to the Diagnostic Criteria for TMD (DC/TMD) Axis I protocol [7]. Participants were given the TMD Pain Screener questionnaire to complete and were examined clinically for TMD signs and symptoms using the DC/TMD Examination Form.

The TMD Pain Screener is an Axis I self-report instrument that consists of 6 items. The first item has scores of 0–2 ($a = 0$, $b = 1$, $c = 2$), while the remaining items are scored simply as $a = 0$ and $b = 1$. A sum is computed and values exceeding the cut-offs of 3 indicate that TMD may be present [8]. Participants were classified as having TMD if they were diagnosed with any one of the ten pain or TMJ disorders listed on the DC/TMD Examination Form. Pain disorders include myalgia, myofascial pain with referral, arthralgia, and headache attributed to TMD. TMJ disorders include disc displacement with reduction, disc displacement with reduction with intermittent locking, disc displacement without reduction and with limited opening, disc displacement without reduction and without limited opening, degenerative joint disease, and dislocation. To come to a diagnosis, indicated history and exam criteria must be met [7].

As diagnostic reliability of self-instruction on the use of the protocol has been proven [9], the examiner (AT) who performed the assessment was trained to perform the DC/TMD examination procedure via an instruction video and documentation available on the International Association for Dental Research (IADR) website.

Outcome measures

The primary outcome was the prevalence of TMD symptoms in patients with and without mandibular asymmetry. The secondary outcomes were the prevalence of the type (pain disorder only, TMJ disorder only, or both pain and TMJ disorders) of TMD, the prevalence of specific TMD diagnoses, and the association between the prevalence of TMD symptoms and variables including demographic data and the magnitude of asymmetry. The sensitivity and specificity of the DC/TMD Pain Screener were also assessed.

Sample size calculation

Based on the reported overall pooled weighted pre-operative prevalence of TMD for orthognathic patients of 32.5% (95% CI 26.7 to 38.9%) in the systematic review and meta-analysis by Al-Moraissi et al. [10] and the reported TMD prevalence in the general population of 5 to 12% [5], the clinical effect size is estimated to be 22.5%. With a type 1 error of 5% and an 80% power, at least 51 subjects are required in each group. Taking into consideration of a possible 10% dropout rate, the adjusted sample size will be 56 subjects per group.

Statistical analysis

The collected data was analyzed with the Statistical Package for Social Sciences (SPSS version 25.0 SPSS Inc., Chicago, IL, USA). Pearson $\chi 2$ and Fisher's exact tests were performed for comparison of TMD prevalence between groups. The statistical significance level was set at 5%.

Results

A total of 134 participants (73 male, 61 female) with a mean age of 24.1 years (range 14 to 55 years, S.D. 6.4 years) were recruited. Moreover, 61.2% (82/134) were diagnosed with mandibular asymmetry and 38.8% (52/134) had grossly symmetrical faces (Table 1).

The prevalence of TMD symptoms among those with mandibular asymmetry was found to be 67.1% (55/82) (95% CI 59 to 75%), which was significantly higher than those without asymmetry (40.4%; 95% CI 32 to 49%, $p = 0.002$). The patients were stratified into three age groups: 20 and below, 21 to 30, and 31 and above. There were no differences in prevalence of TMD among the three age groups ($p = 0.279$). No statistical differences were found between both genders ($p = 0.888$) and among the three skeletal classes ($p = 0.153$). The prevalence of TMD according to the magnitude of asymmetry (2 to 5 mm, 6 to 9 mm, and 10 mm or greater) were 66.7%, 55.6%, and 83.3%, respectively. There were no statistical differences among the different magnitudes of asymmetry ($p = 0.287$) (Table 2).

The overall prevalence of TMD in this population of patients with dentofacial deformities was 56.7% (95% CI 48 to 65%). Pain disorder only was present in 9.7%, TMJ disorder only in 29.9%, and both pain and TMJ disorders in 17.2%.

Table 1 Demographic data of recruited patients, % (*p*)

Gender	
Male	54.5% (73/134)
Female	45.5% (61/134)
Age in years	
20 and below	31.3% (42/134)
21 to 30	56.7% (76/134)
31 or above	11.9% (16/134)
Skeletal class	
Class I	6% (8/134)
Class II	12.7% (17/134)
Class III	81.3% (109/134)
Presence of asymmetry	
Yes	61.2% (82/134)
No	38.8% (52/134)

Table 2 Comparison of TMD prevalence according to selected predictor variables

	Prevalence of TMD, % (*p*)	95% CI	*P* value
Gender			0.888
Male	56.2% (41/73)	0.45 to 0.68	
Female	57.4% (35/61)	0.45 to 0.70	
Age (in years)			0.279
20 and below	47.6% (20/42)	0.32 to 0.63	
21 to 30	59.2% (45/76)	0.48 to 0.70	
31 and above	68.8% (11/16)	0.46 to 0.92	
Skeletal class			0.153
Class I	87.5% (7/8)	0.65 to 1.10	
Class II	47.1% (8/17)	0.23 to 0.71	
Class III	56.0% (61/109)	0.47 to 0.65	
Presence of asymmetry			***0.002***
Yes	67.1% (55/82)	0.57 to 0.77	
No	40.4% (21/52)	0.27 to 0.54	
Magnitude of asymmetry			0.287
2–5 mm	66.7% (32/48)	0.53 to 0.80	
6–9 mm	55.6% (10/18)	0.33 to 0.79	
10 mm or greater	83.3% (10/12)	0.62 to 1.04	

The proportion of patients who were afflicted with TMJ disorders was significantly higher in those who had mandibular asymmetry (54.9%) than those without (34.6%, $p = 0.022$). A higher proportion of those with mandibular asymmetry (31.7%) also suffered from pain compared to those without asymmetry (19.2%), although this difference was not statistically significant ($p = 0.112$) (Tables 3 and 4).

The breakdown of the prevalence of the different TMD diagnoses is listed in Table 5. The most prevalent TMD is disc displacement with reduction (77.6% of all cases with TMD), followed by myalgia (35.5%) and arthralgia (21.1%). Myofascial pain with referral, headaches attributed to TMD, and disc displacement with reduction and intermittent locking were infrequent.

Of those with affected joints, 52.1% had bilateral joints affected, 20.8% had the joint on the same side of chin deviation affected, and 27.1% had the joint on the contralateral side of chin deviation affected. Furthermore, 50.0% of arthralgia

Table 3 Prevalence of the types of TMD symptoms for the overall, asymmetry, and no asymmetry groups, % (*n*)

	Overall (*n*=134)	Asymmetry (*n*=82)	No asymmetry (n=52)
TMD symptoms	56.7% (76)	67.1% (55)	40.4% (21)
Pain disorder only	9.7% (13)	12.2% (10)	5.8% (3)
TMJ disorder only	29.9% (40)	35.4% (29)	21.2% (11)
Both pain and TMJ disorders	17.2% (23)	19.5% (16)	13.5% (7)

Table 4 Comparison of prevalence of type of TMD symptoms between the asymmetry and no asymmetry groups

	Asymmetry (n=82)	No asymmetry (n=52)	P value
With pain, % (n) *(pain disorder only+ both pain and TMJ disorders)*	31.7% (26)	19.2% (10)	*0.112*
TMJ disorder, % (n) *(TMJ disorder only+ both pain and TMJ disorders)*	54.9% (45)	34.6% (18)	***0.022***

occurred on the same side of chin deviation, 30.0% on the contralateral side and 20.0% bilaterally. TMJ disorders affected 53.5% bilaterally, 27.9% on the contralateral side and 18.6% on the same side of chin deviation (Table 6).

The sensitivity and specificity of the Pain Screener are reported in Table 7. A sensitivity of 0.44 and a specificity of 0.93 were demonstrated by the Pain Screener in this study.

Discussion

This study revealed an extremely high pre-operative prevalence of TMD in those with mandibular asymmetry (67.1%, 95% CI 59 to 75%), which was significantly higher than other kinds of dentofacial deformities combined (40.4%; 95% CI 32 to 49% $p = 0.002$). This supports an association between mandibular asymmetry and TMD. The most common TMD is disc displacement with reduction (77.6% among those with TMD). Pain afflicted 26.9% of participants, with a higher percentage affected in the asymmetry group than the group with no asymmetry (31.1% vs. 19.2%), although this difference was not statistically significant. The overall prevalence of TMD in this cohort of patients with dentofacial deformities was 56.7%, lying somewhere in between values reported by two earlier systematic reviews by Al-Moraissi et al. (32.5%) [10] and Al-Riyami et al. (74%) [11]. This is five to ten times higher than the estimated general population average of 5 to 12% [5], indicating a higher prevalence of TMD in those with DFD compared to those without, suggesting dentofacial deformity as a possible etiopathologic factor in TMD. However, this pathophysiological process has yet to be elucidated. Joint overloading is a known pathological factor in the development of TMD internal derangement [12]. It has been hypothesized that mandibular asymmetry and resultant tilting of the frontal occlusal plane induce condylar displacement in the fossa, loading both joints asymmetrically, which then leads to TMJ internal derangement [13]. Further studies assessing patterns of joint loading in those with mandibular asymmetry would be required to validate this hypothesis.

It is correspondingly unclear how the condyle-disc complex is affected in relation to the direction of asymmetric mandibular growth. Our study showed that in those with mandibular asymmetry, TMJ symptoms tended to affect both joints with TMJ disorders (disc displacements) affecting bilateral joints more frequently and arthralgia occurring more commonly on the ipsilateral side. In contrast, the study by Buranastidporn et al., which assessed 392 patients with mandibular asymmetry, found that TMJ symptoms (joint pain, joint sound, or limitation in mouth opening) primarily occurred on the ipsilateral side [14]. However, it should be noted that although the study had a large sample size, the use of a self-administered TMJ history form to diagnose TMJ symptoms is inaccurate. Interestingly, imaging-based studies seem to demonstrate a tendency for disc displacements (TMJ disorders) to occur on the ipsilateral side of chin deviation. A study on 121 Japanese female patients by Ooi et al. found that in

Table 5 Proportions of various TMD diagnoses

Diagnosis	Overall % (p)	Asymmetry % (p)	No asymmetry % (p)
Myalgia	35.5 (27/76)	34.5 (19/55)	38.1 (8/21)
Myofascial pain with referral	1.3 (1/76)	1.8 (1/55)	0 (0/21)
Arthralgia	21.1 (16/76)	20.0 (11/55)	23.8 (5/21)
Headaches attributed to TMD	1.3 (1/76)	1.8 (1/55)	0 (0/21)
Disc displacement with reduction	77.6 (59/76)	78.2 (43/55)	76.2 (16/21)
Disc displacement with reduction with intermittent locking	1.3 (1/76)	1.8 (1/55)	0 (0/21)
Disc displacement without reduction with limited opening	0 (0/76)	0 (0/55)	0 (0/21)
Degenerative joint disease	3.9 (3/76)	1.8 (1/55)	9.5 (2/21)
Dislocation	0 (0/76)	0 (0/55)	0 (0/21)

Table 6 Location of affected joint(s) (arthralgia and/or TMD disorder) in relation to side of chin deviation, % (*p*)

	Ipsilateral side	Contralateral side	Bilateral
Affected joint(s)	20.8% (10/48)	27.1% (13/48)	52.1% (25/48)
Arthralgia	50% (5/10)	30% (3/10)	20% (2/10)
TMJ disorder	18.6% (8/43)	27.9% (12/43)	53.5% (23/43)

*Affected joint = presence of arthralgia and/or TMJ disorder

skeletal class III cases, anterior disc displacement without reduction (ADDwoR) was significantly more common in joints with mandibular asymmetry than those without on magnetic resonance imaging (MRI). ADDwoR was observed only on the deviated side in both skeletal Class II and III mandibular asymmetry cases [15]. Togashi et al. investigated 170 orthognathic patients, of which 19 had asymmetry. CT findings showed high incidences of disc displacement on both sides in patients with mandibular retrusion and on the deviated side in patients with asymmetry. Bone changes (erosion, osteophyte formation, and deformity) were also significantly more prevalent in mandibular retrusion and asymmetry cases. However, the group found no association between the signs and symptoms and CT findings [16]. Mendoza-García et al. analyzed 25 patients (15 with TMD and 10 without) using plain panoramic radiographs and concluded that there is no association between vertical mandibular asymmetry and TMD [17]. Larger prospective studies that incorporate both validated clinical examination protocol and 3D imaging techniques for diagnosis would be valuable in clarifying this incongruity in results.

The DC/TMD Axis I protocol was employed for the assessment of TMD in this study. This evidence-based assessment tool has been validated for use in both clinical and research settings and is the most widely employed diagnostic protocol for TMD research since the publication of its predecessor – the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) in 1992. It includes both a valid screener for detecting any pain-related TMD as well as valid diagnostic criteria for differentiating the most common pain-related TMD (sensitivity ≥ 0.86, specificity ≥ 0.98) and for one intra-articular disorder (sensitivity of 0.80 and specificity of 0.97). Inter-examiner reliability for the clinical assessment associated with the validated DC/TMD criteria for pain-related TMD is excellent (kappa ≥ 0.85) [7], and the diagnostic reliability of self-instruction on the use of the protocol has also been proven [9]. The main limitation of the DC/TMD is the lack of adequate validity for clinical diagnosis of most intra-articular disorders except for disc displacement without reduction with limited opening. The DC/TMD working group recommends imaging as the reference standard for making the diagnoses of the most intra-articular TMD. The Axis I TMD Pain Screener is reported to be a simple, reliable, and valid self-report instrument used to assess for the presence of any pain-related TMD, with sensitivity and specificity ≥ 0.95 [7, 18]. Correspondingly, a high specificity of 0.93 was demonstrated in our study. However, the sensitivity demonstrated was only 0.44. There were a high number of false negatives (i.e., patients diagnosed clinically with pain disorder but had a Pain Screener score of 3 or lower). Whether this could possibly be due to reasons such as patients denying a history of pain when filling up the questionnaire and only confirming a history of familiar pain upon probing by examiner, misdiagnosis by the examiners, or other reasons was not further investigated into.

Table 7 Sensitivity and specificity of the Pain Screener

% (*n*)	True positive	False positive	True negative	False negative
	11.9% (16)	5.2% (7)	67.9% (91)	14.9% (20)

The ambiguity in data reported on TMD and DFD is due in part to the heterogeneity in methodology used and scarcity of good-quality studies in the literature. There is a wide variability in the TMD assessment methods, diagnostic criteria, and classification systems used. Many studies also did not appear to classify TMD according to a validated or universally acceptable scale (i.e., DC/TMD, Helkimo or Cranio Mandibular index). Some authors relied on retrospective data from clinical notes, some diagnosed TMD solely from radiographic findings, and some studies were purely based on patient self-reported questionnaires without corroborating clinical examination. Inadequate sample size that does not provide statistical power is another common issue. This reinforces the need for well-designed prospective studies with the use of standardized TMD diagnostic criteria and classification methods, adequate sample sizes, and matched control groups. We believe that clarifying the picture on how mandibular asymmetry contributes to the development of TMD would be helpful in guiding the choice of surgical treatment modality that could be used to address both the issue of correcting the dentofacial deformity and treating TMD.

In conclusion, the prevalence of TMD in those with mandibular asymmetry was significantly higher than those without, suggesting that mandibular asymmetry could be a possible etiopathologic factor in TMD. Accordingly, we need to be especially cognizant of this condition in our pre-operative, surgical, and post-operative management of this group of orthognathic patients.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee (HKU/HA HKW IRB UW 18-566) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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