Association Between Mandibular Retrognathia and TMJ Disorders in Adult Females

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Abstract

Objective: *This study assesses the association between temporomandibular joint (TMJ) disorders and mandibular retrognathia.* ***Methods:*** *We conducted a case-control study among women, aged 18–70 years, recruited from Kaiser Permanente Northwest Division (KPNW, Portland, OR) and Group Health Cooperative of Puget Sound (GHC, Seattle, WA). Cases (N=160) were women seeking treatment for TMJ disorders at KPNW and GHC clinics. Controls (N=151) were women without TMJ disorders, selected from among adult female dental hygiene patients at KPNW or GHC enrollees. Case status was determined by questionnaire; mandibular sagittal position (orthognathic, mildly retrognathic, severely retrognathic, or prognathic) was measured using digitized facial photographs. Odds ratios (OR) and associated 95 percent confidence intervals (CI) estimated the magnitude of the association between TMJ disorders and mandibular sagittal position.* ***Results:*** *Women with TMJ disorders were 4.0 times (95% CI=1.5, 10.8) more likely than controls to have severe retrognathia; no association with mild retrognathia or prognathia was seen. Results were similar when cases were restricted to those with recent onset of TMJ pain (OR=6.3; 95% CI=1.8, 21.8).* ***Conclusions:*** *We found a strong association between TMJ disorders and severe mandibular retrognathia in adult females. In some women this likely resulted from TMJ disorders influencing mandibular development over time. However, among a subset of women, our data support the reverse hypothesis—that severe mandibular retrognathia may influence the development of TMJ disorders. Despite this strong association, abnormal mandibular position contributed only a small portion to the overall rate at which women sought treatment for TMJ disorders. [J Public Health Dent 2004;64(3):157-63]*

Key Words: mandibular retrognathia, temporomandibular joint disorder, case-control study.

Approximately 5 percent of the general population of the United States older than 15 years of age are affected by temporomandibular disorders (TMD) involving either a muscle or joint (temporomandibular joint or TMJ) that are serious enough to warrant treatment (1,2). TMD prevalence begins to rise in late adolescence and increases through middle age and is associated with female sex, facial trauma, and specific anatomical and occlusal relationships (1,3-13), for example, abnormal mandibular morphology (10-13) or increased overjet, a potential correlate of abnormal mandibular morphology (14). However, less is known about the strength of association or temporal relationship between development of mandibular morphology and development of TMJ disorders (15, 16). Thus, we conducted this study to characterize the association and temporal relationship between abnormal mandibular sagittal position (specifically, mandibular retrognathia) and TMJ disorders in adult females.

Methods

Study Design, Study Population, Assessment of Case Status, and Interview Procedures. We conducted a case-control study between 1998 and 1999 among 18- to 70-year-old female enrollees of two health maintenance organizations, Kaiser Permanente Northwest Division (KPNW, Portland, OR) and Group Health Cooperative of Puget Sound (GHC, Seattle, WA) according to procedures approved by the Human Subject Review Committees of the University of Washington, Group Health Cooperative, and Kaiser Permanente. At KPNW, cases were recruited from the TMD clinic, and controls were recruited from a general dental clinic. Response rates among potential cases and controls approached at KPNW were 95 percent and 80 percent, respectively. At GHC, cases were recruited from the two clinics where patients with suspected TMD are referred, and controls were recruited from a random sample of GHC enrollees who had no computerized record of a TMD diagnosis. Response rates among potential cases and controls approached at GHC were 50 percent and 5 percent, respectively. Case status was determined by the use of a study questionnaire that solicited information pertaining to general demographic characteristics (age, race, level of educational attainment), history of trauma (whiplash injury, facial trauma, clenching), history of orthodontic treatment or associated facial surgery, and history of TMJ symptoms

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TABLE 1
Characteristics of Women with TMJ Disorders (Cases) and Women Without TMJ Disorders (Controls), by Site of Enrollment

	Kaiser Permanent Northwest			Group Health Cooperative			Both Clinic Sites		
Characteristics	Cases (*N*=99) *n* (%)	Controls (*N*=108) *n* (%)	*P*-value*	Cases (*N*=61) *n* (%)	Controls (*N*=43) *n* (%)	*P*-value*	Cases (*N*=160) *n* (%)	Controls (*N*=151) *n* (%)	*P*-value*
Age (years)			.008			.013			.003
56–70	10 (10.1)	11 (10.4)		4 (6.6)	12 (27.9)		14 (8.8)	23 (15.4)	
41–55	21 (21.2)	44 (41.5)		24 (39.3)	18 (41.9)		45 (28.1)	62 (41.6)	
31–40	31 (31.3)	29 (27.4)		16 (26.2)	7 (16.3)		47 (29.4)	36 (24.2)	
18–30	37 (37.4)	22 (20.8)		17 (27.9)	6 (14.0)		54 (33.8)	28 (18.8)	
Race			<.001			.545			<.001
Other	7 (7.1)	9 (8.3)		10 (16.7)	5 (11.6)		17 (10.7)	14 (9.3)	
African-American	1 (1.0)	24 (22.2)		1 (1.7)	2 (4.7)		2 (1.3)	26 (17.2)	
White	91 (91.9)	75 (69.4)		49 (81.7)	36 (83.7)		140 (88.1)	111 (73.5)	
Education			.014			.133			.007
Postbaccalaureate	12 (12.1)	29 (26.9)		15 (24.6)	16 (37.2)		27 (16.9)	45 (29.8)	
College	46 (46.5)	49 (45.4)		28 (45.9)	21 (48.8)		74 (46.3)	70 (46.4)	
High school/less	41 (41.4)	30 (27.8)		18 (29.5)	6 (14.0)		59 (36.9)	36 (23.8)	

*Pearson chi-square.

(clicking, catching, joint pain). For a woman seeking treatment at one of the TMD clinics to be eligible as a case, she had to report the presence of one or more TMJ symptoms; controls could not have any of these symptoms. If the subject reported a history of trauma, orthodontic treatment, or TMJ disorder symptoms, the age at which this first appeared was noted. The dentists staffing the TMD clinics at KPNW and GHC provided diagnoses for the cases according to clinical diagnostic criteria (17). The dentists staffing the general dental clinic at KPNW performed their customary dental exam for the controls following their dental hygiene appointments. Research data for the controls from GHC were collected by the Regional Clinical Dental Research Center at the University of Washington. At KPNW one research assistant was responsible for recruitment, questionnaire administration, and obtaining facial photographs for both cases and controls. At GHC, these duties were divided among several research assistants. All research assistants were unaware of our study hypothesis. We restricted the study to females because females seek treatment much more frequently than do men (3,6).

Assessment of Mandibular Sagittal Position. We took a profile photograph of each participant's face using a Polaroid Spectra camera and Polaroid film to characterize mandibular sagittal position. The subject was positioned in a profile view, exhibiting a natural head posture with the teeth slightly apart. The subject stood five feet away from the wall, with the camera placed two feet from her face. Each photograph was developed, digitized, and stored on a computer for further analysis. On each digitized image, the following three soft tissue landmarks were identified: tragus, soft tissue nasion, and soft tissue B-point. Customized software (Dr. Mostafa Analoui, Indiana University School of Dentistry) was used to construct an angular measurement of mandibular sagittal position, designated the research angle, produced by two intersecting lines, one from tragus to soft tissue nasion, and the other from soft tissue nasion to soft tissue B-point. This angle was measured twice by two individuals (JRM and a research assistant who was unaware of our study hypothesis). The inter- and intrarater reliability of these measurements each exceeded 0.95.

The two measurements obtained by the research assistant were averaged to define the research angles used in this study. The research angles for cases and controls were categorized as orthognathic, mildly retrognathic, severely retrognathic, or prognathic. First, the mean research angle among control subjects was determined to be 70.6 degrees. Next, since we wished these categories to reflect mandibular skeletal patterns, we felt that measures of variance (standard deviation) around the mean should be derived from a standard skeletal measurement rather than the soft tissue research angle. We used a value of 3.7 degrees for the standard deviation, which is a weighted average of the standard deviations for the skeletal angular measurement S-N-B, derived from a population of females aged 12 to 15 (18). The research angles were used to categorize mandibular sagittal position as follows: orthognathic (research angle within one standard deviation of the mean of the control angles or 66.9–74.3 degrees), mildly retrognathic (research angle between one and two standard deviations below the mean of the control angles or 63.2–66.8 degrees), or severely retrognathic (research angle more than two standard deviations below the mean of the control angles or less than 63.2 degrees). Since the association between prognathia and TMJ disorders was not a primary focus of our study, research angles more than one standard deviation above the mean (greater than 74.3 degrees) were broadly classified as prognathic.

Statistical Analysis. Differences between cases and controls were as-

TABLE 2
Prevalence of Temporomandibular Joint Disorders among 160 Cases According to Combination of Diagnoses Provided by Attending Dentist

Type(s) of Pain Present	Disk*	DJD†	Number	%
TMJ pain‡ and muscle pain¶	Yes	No	44	27.5
	Yes	Yes	14	8.8
	No	Yes	4	2.5
	No	No	9	5.7
Muscle pain only¶	Yes	No	36	22.5
	Yes	Yes	4	2.5
	No	Yes	2	1.3
	No	No	22	13.8
TMJ pain only‡	Yes	No	8	5.0
	Yes	Yes	4	2.5
	No	Yes	1	0.6
	No	No	1	0.6
No pain	Yes	No	10	6.3
	Yes	Yes	1	0.6

*Disk displacement, right or left.
†Degenerative joint disease, right or left.
‡TMJ pain (arthralgia, right or left).
¶Muscle pain (myalgia or MPD, right or left).

TABLE 3
Association Between TMJ Disorders and Mandibular Sagittal Position, by Site of Enrollment

Site of Enrollment	Cases (*N*=160) *n* (%)	Controls (*N*=151) *n* (%)	Odds Ratio*	95% Confidence Interval
Kaiser Permanente Northwest				
Mandibular sagittal position				
Prognathic	8 (8.2)	32 (30.2)	0.5	0.2, 1.4
Severely retrognathic	16 (16.5)	3 (2.8)	4.8	1.2, 18.9
Mildly retrognathic	21 (21.6)	13 (12.3)	1.9	0.8, 4.5
Orthognathic	52 (53.6)	58 (54.7)	1.0	Reference
Group Health Cooperative				
Mandibular sagittal position				
Prognathic	3 (5.2)	4 (9.5)	0.3	0.1, 1.9
Severely retrognathic	11 (19.0)	3 (7.1)	3.5	0.8, 15.8
Mildly retrognathic	12 (20.7)	17 (40.5)	0.5	0.2, 1.4
Orthognathic	32 (55.2)	18 (42.9)	1.0	Reference
Both clinic sites				
Mandibular sagittal position				
Prognathic	11 (7.1)	36 (24.3)	0.4	0.2, 1.0
Severely retrognathic	27 (17.4)	6 (4.1)	4.0	1.5, 10.8
Mildly retrognathic	33 (21.3)	30 (20.3)	1.0	0.5, 1.8
Orthognathic	84 (54.2)	76 (51.4)	1.0	Reference

*Odds ratios were adjusted for age, race, and education level. For the combined analysis, odds ratios were further adjusted for site of enrollment.

sessed using two-sample *t*-tests for continuous variables and Pearson chi-square tests for categorical variables. Potential interactions between the research angle (mandibular sagittal position) and other variables, including age, race, education level (i.e., level of educational attainment), and clinic site, were examined. Potential confounders of the association between TMJ disorders and mandibular sagittal position that were examined included age, race, education level, and various forms of trauma, based on the known (or suspected) association between these factors and both TMD (1,3-9) and development of malocclusion (19-22). Multivariable logistic regression analyses were used to calculate odds ratios (OR) and associated 95 percent confidence intervals to assess associations between TMJ disorders (dependent variable) and mandibular sagittal position (independent variable) or other exposures of interest (age, race, education level, whiplash injury, facial trauma, clenching, orthodontic treatment, and facial surgery), adjusted for potential confounders. All data analyses were performed using SPSS (SPSS Inc., Chicago, IL).

Results

Subjects included 160 cases with TMJ disorders (99 from KPNW, 61 from GHC) and 151 controls (108 from KPNW, 43 from GHC). Overall, women with TMJ disorders as compared to controls were younger, more likely to be white, and had attained fewer years of education (Table 1). Over 93 percent of the cases included a diagnosis of joint pain and/or muscle pain (Table 2).

The mean research angle among cases (68.0±4.7 degrees) was lower than among controls (70.6±4.8 degrees, $P<.001$). For both sites combined (KPNW and GHC), women with TMJ disorders were 4.0 times (95% CI=1.5, 10.8) more likely than controls to have severe retrognathia, after adjusting for age, race, education level, and site of enrollment (Table 3). TMJ disorders were not associated with either mild retrognathia (adjusted OR=1.0; 95% CI=0.5, 1.8) or prognathia (adjusted OR=0.4; 95% CI=0.2, 1.0). When the research angle was included as an independent variable in a logistic regression model, each degree decrease in the research angle was associated with a 9.9 percent increase in the risk of a TMJ disorder (data not shown). Also, women with TMJ disorders were less likely to be older, African-American, and highly educated than controls; while women with TMJ disorders were more likely

to have a history of whiplash injury, facial trauma, and clenching than controls (Table 4). No significant interactions were detected between the research angle (mandibular sagittal position) and other covariates measured.

For the 160 participants from KPNW and GHC that were classified as a case according to the study questionnaire, we obtained the TMD diagnosis made by the attending dentist. The TMD classification made by the attending dentist confirmed the presence of a TMJ disorder in 138 (86%) of the 160 cases (Table 2). The 22 remaining cases (14%) were diagnosed by the attending dentist as having only a muscle disorder at the time of examination, although each case reported a history of a TMJ disorder symptom on the questionnaire. When these 22 cases were excluded from the analysis, the association between TMJ disorders and severe retrognathia remained unchanged (adjusted OR=3.9; 95% CI=1.4, 10.8).

We next examined the association between case status and severe mandibular retrognathia among the 44 cases who reported a history of joint pain of two years or less prior to study enrollment. Compared to controls, cases with joint pain of short duration were still significantly more likely (adjusted OR=6.3; 95% CI=1.8, 21.8) to have severe retrognathia (Table 5).

Lastly, based upon the 190,000 eligible women at KPNW during the year this study was conducted (personal communication, Paul Cheek, KPNW), we estimated that adult women sought treatment for TMJ disorders at an overall rate of approximately 5.2 per 10,000 women per year {(99/190,000) * 10,000}. Using this rate, the odds ratios corresponding to the association between TMJ disorders and each mandibular sagittal position category, and the proportion of controls in each category, we were able to estimate that approximately 4, 8, 22, and 2 per 10,000 adult women enrolled at KPNW per year with orthognathic, mildly retrognathic, severely retrognathic, and prognathic mandibles, respectively, sought treatment for a TMJ disorder.

Discussion

Although many previous studies have noted a positive association be-

TABLE 4
Association Between TMJ Disorders and Risk Factors Other than Mandibular Sagittal Position

Both Clinic Sites	Cases (*N*=160) *n* (%)	Controls (*N*=151) *n* (%)	Odds Ratio*	95% Confidence Interval
Age				
56–70	14 (8.8)	22 (15.4)	0.3	0.1, 0.6
41–55	45 (28.1)	62 (41.6)	0.4	0.2, 0.8
31–40	47 (29.4)	36 (24.2)	0.7	0.4, 1.4
18–30	54 (33.8)	28 (18.8)	1.0	Reference
Race				
Other	17 (10.7)	14 (9.3)	0.7	0.3, 1.6
African-American	2 (1.3)	26 (17.2)	0.1	<0.1, 0.2
White	140 (88.1)	111 (73.5)	1.0	Reference
Education level				
Postbaccalaureate	27 (16.9)	45 (29.8)	0.3	0.2, 0.6
College	74 (46.3)	70 (46.4)	0.6	0.3, 1.0
High school/less	59 (36.9)	36 (23.8)	1.0	Reference
Whiplash injury				
Yes	60 (41)	29 (21)	2.8	1.6, 5.0
No	86 (59)	111 (79)	1.0	Reference
Facial trauma				
Yes	49 (34)	12 (9)	5.0	2.3, 10.6
No	95 (66)	125 (91)	1.0	Reference
Clenching				
Yes	131 (87)	33 (24)	19.3	9.9, 37.8
No	20 (13)	105 (76)	1.0	Reference
Orthodontic treatment				
Yes	62 (41)	48 (33)	1.0	0.6, 1.7
No	89 (59)	97 (67)	1.0	Reference
Facial surgery				
Yes	3 (2)	0 (0)	—	—
No	137 (98)	137 (100)	1.0	Reference

For age, race, and education level, the odds ratios were adjusted for the other two variables, as well as site of enrollment. For whiplash, facial trauma, clenching, orthodontic treatment, and facial surgery, the odds ratios were adjusted for age, race, education level, and site of enrollment.

TABLE 5
Association Between TMJ Disorders and Mandibular Sagittal Position with Cases Restricted to Women with Duration of Pain ≤2 Years, Prior to Study Enrollment

Both Clinic Sites	Cases (*N*=44) *n* (%)	Controls (*N*=151) *n* (%)	Odds Ratio*	95% Confidence Interval
Mandibular sagittal position				
Prognathic	2 (4.8)	36 (24.3)	0.5	0.1, 2.4
Severly retrognathic	10 (23.8)	6 (4.1)	6.3	1.8, 21.8
Mildly retrognathic	11 (26.2)	30 (20.3)	1.6	0.6, 4.2
Orthognathic	19 (45.2)	76 (51.4)	1.0	Reference

Odds ratios were adjusted for age, race, education level, and site of enrollment.

tween TMJ disorders and abnormal mandibular morphology, the strength of the observed associations was unclear (5,10-13,23-27). We found a strong association in adult females between TMJ disorders and severe retrognathia (OR=4.0). A previous study found the risk of certain TMJ disorders increased as overjet increased and that an overjet of 6 mm was associated with an odds ratio of approximately two (14). Although overjet was not measured in our study, it is possible that cases with severe retrognathia had an average overjet greater than 6 mm. This might, in part, explain the stronger association we observed.

The association between age, sex, and temporomandibular disorders (TMD) has been extensively studied; while the relationship between race, socioeconomic status, and TMD has been less studied (1,3-6,8). Since TMJ disorders are a subset of TMD and therefore less prevalent, it has been harder to study TMJ disorders. Thus, less is known about the relationship of demographic factors (age, race, sex, socioeconomic status) to TMJ disorders than to TMD. We found that TMJ disorders were associated with younger, white, and less educated adult women. Interestingly, adult women with TMJ disorders were much less likely to be African-American than were controls, something not previously well recognized. We also found TMJ disorders to be associated with history of whiplash injury, facial trauma, and clenching, consistent with previous studies (7,9,28), although recall bias may have contributed to some of these strong associations.

In the current study, women presenting for TMJ treatment reported a wide range of symptom duration prior to study enrollment. If the presence of a TMJ disorder alters mandibular development over time, then one would not expect to observe an association between TMJ disorders and severe mandibular retrognathia among individuals with recent onset of TMJ symptoms. However, in the current study, we found the association between TMJ disorders and severe mandibular retrognathia remained strong when the analysis was restricted to cases with joint pain of short duration (OR=6.3). This supports the hypothesis that in certain cases severe retrognathia may precede the onset of TMJ disorders and potentially contribute to their etiology.

Examination by experienced and calibrated dentists is the gold standard for diagnosing temporomandibular disorders (29-31). Because experienced dentists were only available to diagnose the cases, we used a study questionnaire to identify cases and controls. In a previous study conducted at GHC, a questionnaire proved useful in categorizing a random sample of GHC enrollees by TMD pain status (6). Our study questionnaire proved equally useful in correctly classifying 86 percent of our cases, when compared to the diagnoses provided by their dentists. Furthermore, the association between TMJ disorders and severe mandibular retrognathia remained unchanged after excluding the 14 percent of cases with only muscle disorders upon examination.

Similarly, we are confident that our protocols used for selecting controls were valid. First, the prevalence of serious TMJ disorders in adult females is low. Since many TMJ disorders are chronic conditions, we felt that the incidence of TMJ disorders would be quite low during the study period. Thus, it is extremely unlikely that a dental hygiene patient presenting to a general dental clinic at KPNW, or a woman randomly selected from the list of GHC enrollees who did not report a history of symptoms consistent with a TMJ disorder, would have a previously undiagnosed serious TMJ disorder. Further, if any woman had a serious TMJ disorder, she would have been referred to one of the clinics from which cases were recruited.

Although the gold standard for measuring mandibular retrognathia is the lateral cephalometric radiograph, facial photographs have proven to provide reliable and valid measurements of mandibular sagittal position, particularly when all measurements are obtained by one individual (32-37). Moreover, our research angle was constructed to be highly correlated with the degree of abnormality in the underlying skeletal pattern. However, since we believed that variability in the research angle (a soft tissue angle) among the controls would be greater than the corresponding variability in the underlying skeletal pattern, we chose to base our assessment of the degree of departure from the mean of the research angles among controls on published data for a standard skeletal measurement similar to our research angle (18).

Although the overall rate at which adult women at KPNW sought treatment for TMJ disorders (5.2/10,000 per year) was small, this may not be an accurate estimate of the rate at which women develop TMJ disorders, since it is likely that many women either do not seek treatment or delay seeking treatment. Also, even though adult women at KPNW with severe retrognathia had more than a fourfold increased risk of TMJ disorders compared to orthognathic women, the actual number of women with severe retrognathia who sought treatment each year was still quite small (22/10,000 per year). Furthermore, we estimated the excess number of women who sought treatment for TMJ disorders who were severely retrognathic, was 18/10,000 per year [obtained by taking the rate among severely orthognathic women (22/10,000 per year) and subtracting the rate among orthognathic (normal) women (4/10,000 per year)].

Additionally, the difference between the overall rate at KPNW (5.2/10,000 per year) and the rate for women with orthognathic mandibles (4.0/10,000 per year) demonstrates that abnormal mandibular sagittal position (severe retrognathia, mild retrognathia, prognathia) contributed only a small portion (less than 25%) to the overall rate at which women sought treatment for TMJ disorders. This corresponds to the statement by Pullinger et al. (14) that occlusal variables "described only a small proportion of the variation in each disease group and did not explain the majority of the disease occurrences."

Our study does have some potential limitations. First, although the high response rates at KPNW reduce the possibility that selection bias unduly influences results obtained at KPNW, the lower response rates among cases and controls at GHC increase the potential for selection bias due to nonresponse at this site. However, we present our results from each study site separately, in addition to the combined results adjusted for site of enrollment. Second, although we recognize that the use of calibrated dental examiners to assess case status, and the use of lateral cephalometric radio-

graphs to more accurately measure mandibular sagittal position would have strengthened our study, neither was available. However, procedures for administering our study questionnaire and obtaining and analyzing facial photographs were comparable for both cases and controls, and both have been used successfully in previous investigations (6,35). Third, because our study only included women, it is unknown whether our observed association between TMJ disorders and severe retrognathia can be generalized to men. Further, because women in our study were seeking treatment for TMD, it is unknown whether our findings can be generalized to individuals not seeking treatment.

In summary, we found a strong association between TMJ disorders and severe mandibular retrognathia in adult females. In some women this likely resulted from TMJ disorders influencing mandibular development over time. However, among a subset of women, our data support the reverse hypothesis—that severe mandibular retrognathia may influence the development of TMJ disorders. Despite this strong association, abnormal mandibular position contributed only a small portion to the overall rate at which women sought treatment for TMJ disorders.

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