Original Article

Craniofacial Asymmetry and Temporomandibular Joint Internal Derangement in Female Adolescents: A Posteroanterior Cephalometric Study

Biljana Trpkova, DDS, MSc[a]; Paul Major, DDS, MSc, MRCD(C)[b]; Brian Nebbe, BDS, Mdent, FFD (SA) Ortho, PhD[c]; Narasimha Prasad, PhD[d]

Abstract: Unilateral or bilateral pathology of the osseous components of the temporomandibular joint (TMJ) can result in pronounced facial asymmetry because of dissimilar size and shape of the right and left sides of the mandible. To date, it is unknown whether abnormalities of the soft tissues of the TMJ are associated with greater than normal craniofacial asymmetry. In this study, we investigated the amount of craniofacial asymmetry in female orthodontic patients with unilateral or bilateral TMJ internal derangement (TMJ ID) relative to the amount in female patients without TMJ ID. The total sample consisted of 80 female adolescents. Bilateral TMJ magnetic resonance images were used as a database for objectively scoring the severity of TMJ ID. Craniofacial asymmetry was measured from posteroanterior cephalograms. Females with bilateral TMJ ID had significantly greater asymmetry in the vertical position of the antegonion. If the TMJ ID was more advanced on the right side, the ipsilateral ramus was shorter, resulting in significant asymmetry in this region. In all other craniofacial regions, the amount of asymmetry was not significant between females with normal TMJs and those with TMJ ID. The results indicate that a female orthodontic patient with bilateral TMJ ID or unilateral right TMJ ID may present with or develop a vertical mandibular discrepancy. (*Angle Orthod* 2000;70:81–88.)

Key Words: TMJ internal derangement, Asymmetry, Posteroanterior cephalogram

INTRODUCTION

One of the goals of orthodontic treatment is creating a balanced and harmonious facial appearance. One aspect of this harmony is craniofacial symmetry. However, minor asymmetry is a desirable variation of the craniofacial structures because we perceive these little inconsistencies as esthetically pleasing.[1,2] Although facial asymmetry exists in individuals with normal facial appearance,[3–11] there is no consensus concerning its degree, side prevalence, or localization. A larger left side has been reported by several authors,[3–6] while others have reported a larger right side.[2, 7–9] Asymmetry of the craniofacial complex may be greater in childhood and adolescence because of relative growth imbalances between the right and left sides.[10] Mandibular asymmetry may fluctuate in magnitude and side prevalence with increasing age.[10,12] Facial asymmetry in children and adolescents might be related to gender.[8] In the adult population, no gender-associated differences in craniofacial asymmetry have been reported.[6,9]

Orthodontists generally use visual analysis to determine facial balance for their patients.[13] In the treatment-planning process, additional tests or imaging are ordered if the asymmetry appears clinically significant or if patients have conditions previously associated with asymmetry. For instance, temporomandibular joint (TMJ) pathology, such as degenerative joint disease, has been recognized as an important factor in growth disturbances, including mandibular deficiency and open bite.[14,15] Occlusal instability, vertical facial asymmetry, and chin deviation to the affected side are other clinical signs associated with TMJ pathology.[16]

Internal derangement (ID), ie, disc displacement of the TMJ, is a common intra-articular disorder characterized by an abnormal relationship of the articular disc relative to the mandibular condyle, fossa, and articular eminence. Almost 80% of patients with temporomandibular joint disorders (TMD) have a form of internal derangement.[17–20] TMJ in-

[a] Clinical Assistant Professor, TMD Investigation Unit, Department of Oral Health Sciences, University of Alberta, Canada.

[b] Director, TMD Investigation Unit, Department of Oral Health Sciences, University of Alberta, Canada.

[c] Clinical Assistant Professor, TMD Investigation Unit, Department of Oral Health Sciences, University of Alberta, Canada.

[d] Department of Mathematical Sciences, University of Alberta, Canada.

Corresponding author: Dr. Biljana Trpkova, Department of Oral Health Sciences, 5069, Dentistry/Pharmacy Centre, University of Alberta, Edmonton, Canada T6G 2N8 (e-mail: btrkova@gpu.srv.ualberta.ca).

Accepted: August, 1999. Submitted: January, 1999.

ternal derangement has been found in 94% of the pediatric TMD population.[21] When magnetic resonance imaging (MRI) has been used in asymptomatic orthodontic juvenile patients, disc displacement has been discovered in 5%[22] to 11.8% of patients.[23]

Juvenile TMD patients may have a smaller overall mandibular length, shorter posterior facial height, shorter ramus and corpus, larger gonial angle, and steeper mandibular plane than adults.[24,25] Several authors have suggested that both TMJ internal derangement and degenerative joint disease could be the main causes for mild to moderate facial asymmetry because of mandibular growth deficit in a growing child or adolescent.[16,26–30]

The degree to which TMJ disorder can affect facial growth might depend on the time of onset and the duration of the condition.[31] The severity of the disorder and the side it involves are other important questions to consider.[24]

The objective of this cross-sectional study was to explore whether TMJ internal derangement is associated with greater-than-average craniofacial asymmetry in a sample of growing female patients.

MATERIALS AND METHODS

Sample

The subjects were Caucasian females between the ages of 10 and 17 years, with no history of infection, tumors, rheumatologic disease, or other clinically significant pathology affecting the craniofacial region. Subjects were recruited from the Graduate Orthodontic Clinic at the University of Alberta and from a private orthodontic practice in the area prior to undergoing orthodontic treatment. The group consisted of orthodontic patients with or without clinically detectable TMJ signs and symptoms. In addition, practicing orthodontists in the Edmonton area were asked to screen preorthodontic patients for signs and symptoms of TMJ ID and to refer symptomatic individuals for MRI evaluation, if consent was obtained. Each patient received bilateral TMJ magnetic resonance imaging at the Magnetic Resonance Centre of Edmonton, using a 1.0 Tesla machine (Shimadzu Corporation 3, Tokyo, Japan). Bilateral closed-mouth sagittal sections perpendicular to the condylar long axis were obtained with a unilateral 3-inch surface receiver coil. T1-weighted 500/20 (repetition time ms/echo time ms) pulse sequences were performed, using a slice thickness of 3 mm, a 140-mm field of view, a number of excitations of 2, and an image matrix of 204 × 204. Mandibular position in centric occlusion was secured with polyvinylsiloxane bite registration (President Jet-Bite, Coltane/Whaledent Inc, Mahwah, NJ). Only females were included in this investigation because the number of males with TMJ ID established with MRI was insufficient for further study.

Closed-mouth lateral cephalograms and posteroanterior (PA) cephalograms were obtained at Edmonton Diagnostic Imaging with a Siemens OP10 radiographic machine (Siemens, Bensheim, Germany) set for standardized exposure. Head positioning was maintained with Frankfort horizontal parallel to the floor. Mandibular position during exposure was reproduced using the same centric occlusion bite registration used during the MRI procedure.

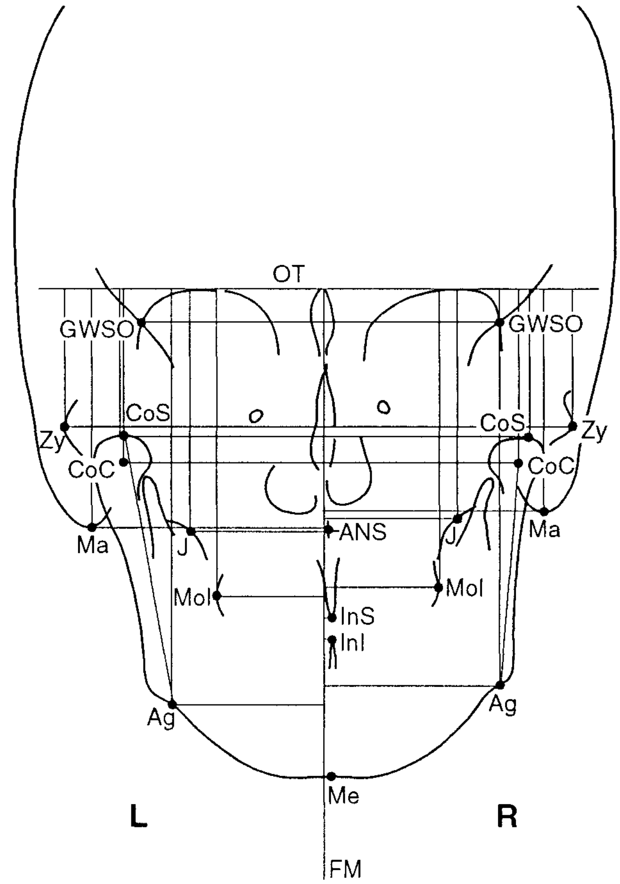

FIGURE 1. Cephalometric landmarks, reference planes, and asymmetry measurements.

The records of 80 females (mean age, 13.20 years; SD, 1.70; range, 10.01 years to 16.64 years) were available for this study.

Cephalometric analysis

All radiographs were traced twice by 1 observer on transparent acetate paper using a 0.3-mm 3H Pentel 120 A3DX (0.3 mm) A313 Tokyo, Japan pencil. The choice of landmarks was based on previously published PA cephalometric reproducibility studies.[32] Landmarks were registered manually. Six bilateral skeletal, 1 dental bilateral, 2 skeletal midline, and 2 dental midline points were identified. Orbita tangent (OT) represented the horizontal reference plane. The vertical reference plane, ie, the facial midline (FM), was constructed as a line passing through the midpoint between the intersections of the greater wing of the sphenoid bone and the orbital margin (GWSO), perpendicular to the OT (Figure 1). Deviations from the midline were also mea-

TABLE 1. Cephalometric Landmarks, Reference Planes, and Asymmetry Measurements

Parameter	Description
Bilateral landmarks	
ZY	Zygomatic point—lateralmost aspect of the zygomatic arch
Ma	Mastoid point—inferiormost point on the mastoid process
CoS	Condyle superior—superiormost aspect of the mandibular condyle
CoC	Condyle center—center of the mandibular condylar head
JP	Jugal point—deepest point on the curve of the malar process of the maxilla
Ag	Antegonion—deepest point on the curvature of the antegonial notch
Mol	Maxillary first molar—midpoint on the buccal surface of the maxillary first molar
Midline landmarks	
ANS	Anterior nasal spine—center of the intersection of the nasal septum and the palate
Me	Menton—midpoint on the inferior border of the mental protuberances
InS	Incisor superior—upper dental midline, contact point between maxillary central incisors
InI	Incisor inferior—lower dental midline, contact point between mandibular central incisors
Mandibular ramus height	
Ramus R	Distance from superiormost point on outline of right mandibular condyle to ipsilateral antegonion (CoSR-AgR)
Ramus L	Distance from superiormost point on outline of left mandibular condyle to ipsilateral antegonion (CoSR-AgL)
Horizontal reference plane	
OT	Orbita tangent—line connecting uppermost points on superior outline of right and left orbits
Vertical reference plane	
FM	Facial midline—perpendicular to orbita-tangent line, drawn through midpoint of distance between right and left GWSOs
GWSO	Greater wing superior orbit—intersection of the superior border of the greater wing of the sphenoid bone and orbital outline
Bilateral asymmetry variables	
ZyH%	Zygomatic horizontal—width difference between right and left sides
ZyV%	Zygomatic vertical—height difference between right and left sides
CoSH%	Condyle superior horizontal—width difference between right and left sides
CoSV%	Condyle superior vertical—height difference between right and left sides
CoCH%	Condyle center horizontal—width difference between right and left sides
CoCV%	Condyle center vertical—height difference between right and left sides
MaH%	Mastoid horizontal—width difference between right and left sides
MaV%	Mastoid vertical—height difference between right and left sides
MolH%	First molar horizontal—width difference between right and left sides
MolV%	First molar vertical—height difference between right and left sides
JH%	Jugal horizontal—maxillary width difference between right and left sides
JV%	Jugal point vertical—maxillary height difference between right and left sides
AgH%	Antegonion horizontal—mandibular width difference between right and left sides
AgV%	Antegonion vertical—mandibular height difference between right and left sides
Ramus%	Ramus height difference between right and left sides

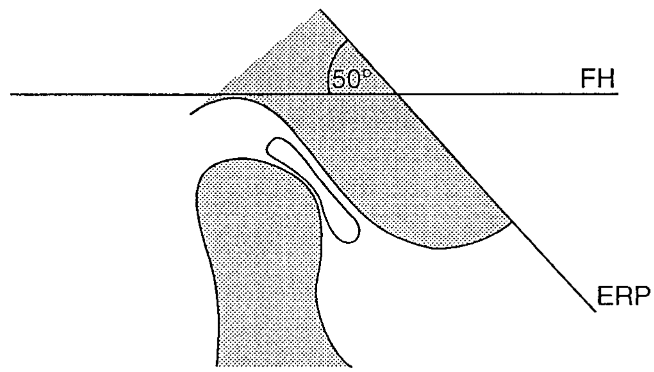

FIGURE 2. Establishment of a plane for quantitative MRI assessment. FH indicates Frankfort horizontal; ERP, eminence reference plane.

sured as the perpendicular distance from the midpoints of the facial skeleton to the facial midline. The landmarks and reference planes used are defined in Table 1.

Analysis of asymmetry. Seven paired horizontal and 7 paired vertical variables, as well as ramus height on the right (R) and left (L) sides, were obtained for each tracing. Differences between the right and left sides for each measurement were used to calculate asymmetry according to the formula $(R - L)/(R + L) \times 200$. Deviations of the midline landmarks from the facial midline provided 4 asymmetry variables, which were assigned a positive value if skewed to the right and a negative value if skewed to the left. Nineteen asymmetry variables were collected for each patient.

MRI analysis. Quantitative measures of disc displacement and disc length for each joint were obtained from consecutive sagittal MRI slices (produced from 3-mm–thick volume slices, 4 to 6 slices per joint) using the procedure described by Nebbe et al.[33] Each MRI slice was traced by 1 investigator (BN) to determine the relationship between the osseous articular structures and the articular disc. As a first step in the MRI analysis, Frankfort horizontal was transferred from the corresponding lateral cephalometric

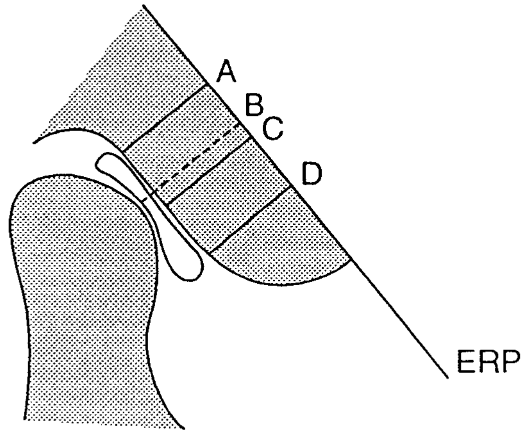

FIGURE 3. Reference points for determining disc length and disc displacement. (A) Posterior band. (B) Condylar load point. (C) Midpoint of disc. (D) anterior band.

tracing onto the MRI tracing. A reference plane was then drawn as a line that intersected the patient's Frankfort horizontal at a 50° angle through a point 10 mm anterior to the maximum height of the articular fossa. (Figure 2) The condylar load point (CLP) was determined as the shortest distance between the condyle and the articular eminence along a line perpendicular to the reference plane. Three landmarks were identified on the contours of the articular disc: anterior band, posterior band, and midpoint of the disc (Figure 3). From each landmark, perpendicular lines were erected to the constructed reference plane. Disc displacement was measured as the distance from the midpoint of the disc to the CLP along the reference plane. Negative values for disc displacement implied that the midpoint of the disc was posterior to the condylar loading point and represented a variation of normal disc position. Disc length was measured as the distance from the anterior to the posterior band of the disc along the reference plane. A negative correlation between disc displacement and disc length has been described.[33] To produce a positive correlation between these 2 scores, each measurement for disc length was subtracted from a calculated value for normal disc length of 10 mm. The values thus obtained ranged from negative values, representing disc length greater than 10 mm (and therefore normal), to positive values describing shortening of the disc of increasing severity. In this way, several variables measuring disc displacement and disc length were obtained per joint. Principal components analysis (SPSS for Windows, SPSS Inc, Chicago, Ill) was used to integrate the measurements from each slice into 2 single weighted scores for each joint, 1 for disc displacement and 1 for disc length. The same statistical procedure was used to synthesize disc displacement and disc length scores of each patient into 1 total score for TMJ ID for the right (TMD ID R) and for the left (TMD ID L).

Method error

Cephalometric measurement error was determined on repeated tracings of each cephalogram, obtained and measured with a minimum of a 1-week interval. Dahlberg's formula[34] was used to calculate the mean, standard deviation, and range of standard error for paired and midline measurements.

To estimate MRI measurement, 10 MRIs representing normal disc position and 10 representing internal derangement were selected and randomly traced 5 times on consecutive days. A multivariate analysis of variance (MANOVA) procedure with MRI tracings as repeated measures produced an F-statistic and a coefficient of intrarater reliability R (Rel = 1 − 1/F).[35] Disc length and disc displacement coefficients of reliability were excellent, at 1.00 to 0.98, respectively.

Statistical methods

Two separate cluster analyses were performed. TMJ ID R minus TMJ ID L (R − L), or the side difference between TMJ ID within patient (measure of TMJ ID asymmetry), and TMJ ID R plus TMJ ID L (R + L), or the sum of bilateral TMJ ID scores for each patient (measure of severity of TMJ internal derangement) were used to group the patient population into 4 categories according to the severity and location (unilateral or bilateral) of TMJ ID. In this way, 3 cluster categories of patients were produced: Patients with both (R − L) and (R + L) close to zero (patients with bilaterally normal TMJs; cluster category I), patients with positive (R − L) and positive (R + L) scores (patients with right unilateral TMJ ID) and patients with negative (R − L) and positive (R + L) scores (patients with left unilateral TMJ ID; both, cluster category II), and patients with (R − L) close to zero and positive (R + L) scores (patients with bilaterally abnormal TMJs of approximately equal severity; cluster category III).

The difference between the right and left TMJ ID scores was also used to categorize patients according to the side where the internal derangement was more advanced. Three more cluster categories were obtained: Patients with no difference in TMJ status between the right and left side (patients with bilaterally normal TMJs and with bilateral TMJ ID of equal severity; cluster category IV), patients with positive (R − L) scores (patients with unilateral TMJ ID on the right side and with bilateral TMJ ID of greater severity on the right side; cluster category V), and patients with negative (R − L) scores (patients with unilateral TMJ ID on the left side and with bilateral TMJ ID of greater severity on the left side; cluster category VI).

The presence of normal asymmetry in the sample was calculated in the following way: the mean asymmetry for each variable in the group with normal TMJs was subtracted from the respective mean value for the entire patient population. These differences were then added to each patient's corresponding reading for each craniofacial asymmetry measurement.

A one way ANOVA method was used to test whether the mean values of craniofacial asymmetry measures between cluster categories were significantly different.

Multiple linear regression was used to analyze the relationship between all craniofacial asymmetry variables as independent variables and TMJ ID scores as dependent variables. The influence of age on craniofacial asymmetry and TMJ ID scores was tested and factored out prior to further regression analyses. Multiple linear regression analysis was also used to study the relationships between the following variables:

1. Right-side TMJ ID score and absolute values of craniofacial asymmetry measurements.
2. Left-side TMJ ID score and absolute values of craniofacial asymmetry measurements.
3. Right-side TMJ ID score minus left-side TMJ ID score (R − L) and signed craniofacial asymmetry measurements, testing both the direction and the amount of asymmetry.
4. Right-side TMJ ID score plus left-side TMJ ID score (R + L) and absolute craniofacial asymmetry measurements, testing the severity of bilateral TMJ ID and severity of asymmetry.

The statistical significance level for all analyses was set at the 5% level.

RESULTS

For the purposes of this study, acceptable margins of error were set at 1% for paired asymmetry measures and at 1 mm for midline asymmetry measures. Errors of most paired asymmetry measures and of all 4 midline measures did not exceed acceptable limits. The mean of the standard error for midline measurements ranged from 0.30 mm for the anterior nasal spine (ANS) to 0.72 mm for the menton (Me). Variables that had more than 1% measurement error were zygomatic vertical (ZyV%), mastoid horizontal (MaH%), and jugal horizontal (JH%), and these were considered with caution in further analysis.

Asymmetry in patients without TMJ ID was calculated as presented in Table 2. Classifications of patients according to cluster analyses are listed in Tables 3 and 4. Forty-seven percent of patients had some form of TMJ ID. Twenty-nine percent had unilateral TMJ ID (16% involving the right TMJ and 13% involving the left TMJ), whereas 19% had a bilateral TMJ ID. Tables 5 and 6 contain the one way ANOVA outcome when means of craniofacial asymmetry measures were compared between cluster groups.

The results obtained with multiple linear regression are presented in Table 7. The purpose of this analysis was to determine which asymmetry measurements might be significantly associated with TMJ ID and therefore used to explain TMJ ID.

TABLE 2. Range of Asymmetry in Adolescent Females Free of Temporomandibular Joint Internal Derangement*

Variable	Mean, %	SD, %
AgH%	−1.88	10.32
AgV%	−0.60	2.76
CoCH%	−1.17	7.34
CoCV%	0.67	5.21
CoSH%	−1.52	7.52
CoSV%	−1.98	31.52
JH%	−0.08	9.71
JV%	0.52	2.85
MaH%	−4.16	9.29
MaV%	0.10	4.93
MolH%	−1.80	8.34
MolV%	0.38	2.29
ZyH%	−1.66	4.64
ZyV%	1.13	6.63
Ramus%	−0.78	2.09
ANS-FM	0.25	1.08
InS-FM	0.43	1.43
InI-FM	0.22	1.68
Me-FM	1.12	3.16

* Negative values represent left side dominance.

TABLE 3. Cluster Groups Formed by Combining TMJ ID Scores*

		Cluster Center	
Cluster Group	Patients, n (%)	(R − L)	(R + L)
I. Bilateral normal TMJ	42 (52.5%)	−0.124	−1.3414
II. Unilateral TMJ ID R*	13 (16.25%)	1.2534	0.5919
II. Unilateral TMJ ID L*	10 (12.5%)	−1.5612	0.7210
III. Bilateral TMJ ID	15 (18.75%)	−0.631	2.9246
Total	80		

* TMJ indicates temporomandibular joint; ID, internal derangement; R, right TMJ ID score; and L, left TMJ ID score.

TABLE 4. Cluster Groups Based on TMJ ID Scores and TMJ ID Side Dominance: Right TMJ ID Score Minus Left TMJ ID Score*

Cluster Group	Patients, n (%)	Cluster Center, (R − L)
IV. No side dominance	52 (65%)	−0.0391
V. Right side dominant	16 (20%)	1.2815
VI. Left side dominant	12 (15%)	−1.6046
Total	80	

* TMJ indicates temporomandibular joint; ID, internal derangement; R, right TMJ ID score; and L, left TMJ ID score.

DISCUSSION

The results revealed that for most craniofacial regions, the amount of asymmetry did not differ significantly between females with normal TMJs and those with either unilateral or bilateral TMJ ID (Tables 5 and 6). These findings were expected for upper and middle craniofacial structures. The deviation of the anterior nasal spine from the facial

TABLE 5. ANOVA Comparisons of Amount of Asymmetry (Absolute Values of Asymmetry Measurements) for Cluster Groups I, II, and III

Craniofacial Measurement	*P* value	Observed Means for Each Cluster Group: I (n = 42)	II (n = 23)	III (n = 15)
ANS-FM abs (mm)	.009*	0.770	1.320†	0.708
InS-FM abs (mm)	.201	1.098	1.565	1.385
InI-FM abs (mm)	.098	1.188	1.879	1.481
Me-FM abs (mm)	.400	2.094	2.446	2.908
AgH%	.305	5.640	6.492	8.398
AgV%	.050*	2.367	3.594	4.968†
CoCH% abs	.774	4.032	3.701	3.301
CoCV%	.733	3.531	4.174	4.079
CoSH%	.539	4.122	3.984	2.947
CoSV%	.973	5.061	5.360	5.209
MaH%	.932	5.477	5.993	5.464
MaV%	.678	3.119	3.513	3.943
MolH%	.573	6.055	7.466	6.129
MolV%	.941	1.182	1.240	1.328
JH%	.562	4.355	5.745	4.704
JV%	.391	1.768	1.518	2.317
ZyH%	.584	2.752	2.346	3.213
ZyV%	.667	4.116	4.698	4.671
Ramus%	.906	1.5517	1.710	1.587

† Significantly different from the other 2 groups in the same row, * $P < .05$.

TABLE 6. ANOVA Comparisons of Means of Asymmetry for Craniofacial Measurements Between Cluster Groups IV, V, and VI

Craniofacial Measurement	*P* value	Observed Means for Each Cluster Group: IV (n = 52)	V (n = 16)	VI (n = 12)
ANS-FM abs (mm)	.190	0.589	0.501	1.192
INS-FM abs (mm)	.820	0.876	0.725	1.103
INI-FM abs (mm)	.666	0.909	1.316	0.725
Me-FM abs (mm)	.749	2.060	2.211	1.410
AgH%	.931	1.963	2.889	1.617
AgV%	.684	−3.386	−1.724	−1.600
CoCH% abs	.784	−0.153	−1.393	0.008
CoCV%	.242	−1.554	1.033	−2.250
CoSH%	.734	−0.564	−1.850	0.0213
CoSV%	.268	2.825	6.122	1.880
MaH%	.648	−3.422	−5.783	−4.420
MaV%	.447	−0.312	−0.601	−2.491
MolH%	.877	2.376	2.205	0.859
MolV%	.247	−0.006	1.185	0.636
JH%	.635	1.880	0.866	−0.772
JV%	.547	0.247	1.063	−0.091
ZyH%	.716	−1.395	−1.579	−2.526
ZyV%	.411	1.362	3.071	−1.769
Ramus%	.002*	−0.653	−2.452†	0.214

† Significantly different from the other 2 groups in the same row, * $P < .05$.

TABLE 7. Multiple Linear Regression Analysis Results. Asymmetry Measurements Significant in Explaining the Variability of the Dependent Variables R, L, (R − L), and (R + L)

Dependent Variable	Adjusted R^2	Independent Variable	*P* value	Correlation Coefficient
R	0.103	AgV% abs	.014	+0.276
		Ramus% abs	.036	+0.240
L	0.036	CoSH% abs	.038	−0.115
(R − L)	0.206	Ramus%	.001	−0.407
		ANS-FM	.022	−0.178
		InI	.020	+0.152
(R + L)	0.046	ANS-FM.abs	.031	−0.241

* R indicates right temporomandibular joint internal derangement score; L, left temporomandibular joint internal derangement score.

midline (ANS − FM) in patients with unilateral TMJ ID was 0.6 mm greater for females with normal joints, which was not clinically significant. We expected differences in the lower facial regions, especially between patients with unilateral TMJ ID vs bilateral TMJ ID or bilaterally normal TMJs. The amount of vertical asymmetry in the region of antegonion was significantly different between the first 3 cluster categories. However, contrary to expectations, a greater amount of asymmetry was found in patients with bilateral TMJ ID (4.96%) compared with females with bilaterally normal TMJs (2.36%), whereas females with unilateral TMJ ID did not differ significantly from the other 2 groups (3.59%). Asymmetry appeared to progress from group I to group III. Time differences in the onset of TMJ ID in patients with bilateral TMJ ID, on one side first and then on the other, could explain this finding. We had no knowledge about the exact time of onset or the duration of the changes within the TMJs. Bilateral TMJ ID likely develops over a longer time period than does unilateral TMJ ID; therefore, bilateral TMJ ID can have a greater influence on facial development. In children and adolescents with juvenile rheumatoid arthritis (JRA), reduced ramus and total face height consistently support the idea that mandibular growth fails to proceed at a normal rate.[36–38] Greater variance of ramus height asymmetry and overall mandibular length asymmetry has been demonstrated in JRA patients as compared with healthy children, whereas transverse mandibular dimensions were similar to controls.[38,39] In adult patients with JRA, mandibular asymmetry is infrequent.[40] These studies imply that the time period between 7 years and 17 years may be a transitional stage from unilateral to bilateral growth retardation. A similar concept could apply to internal derangement of the TMJs. Available literature suggests that mild-to-moderate asymmetry of unknown etiology tends to improve with growth.[10,12]

Cluster groups IV, V, and VI allowed us to compare both the magnitude and the direction of asymmetry in relation to TMJ ID asymmetry. The one measurement significantly different for cluster groups IV, V, and VI was ramus height (Table 6). In this instance, patients with TMJ ID dominant on the right side had a shorter right ramus, as expressed with the negative mean value of ramus percentage (−2.452%), compared with patients who had dominant left ID (0.2148%) and those with similar left and right TMJ disc status (−0.6536%). Although the direction confirmed a trend, the magnitude of asymmetry did not appear to be clinically significant. In an experimental study on rabbits, it has been shown that TMJ ID can significantly affect further mandibular growth, specifically ramus height.[30] However, a shorter ramus on the disc displacement side can be partially compensated for by growth at the base of the mandible, so that the overall height of the mandible (ramus and body) may not be reduced.[30]

Our patients who were free of TMJ ID showed dominance of the left side of the face (Table 2). We assume that a pre-existing left side dominance could help explain why ramus height was more asymmetric in cluster group V (unilateral right TMD ID), whereas in cluster group VI (unilateral left TMD ID) the amount or direction of asymmetry did not differ significantly (Table 7). Preexisting ‘‘normal’’ asymmetry can either camouflage or exaggerate any reduction or lack of condylar growth in the TMJ. For instance, in a patient with left unilateral TMJ ID, or a bilateral TMJ ID that started on the left side, a preexisting left-side asymmetry will be neutralized by the reduced growth on the left side, and therefore may not result in an increase of asymmetry. The opposite situation, a right unilateral (or bilateral TMJ ID that has started on the right side) and a preexisting left-side asymmetry will result in even more pronounced asymmetry with a dominating left side as the right side lags in growth.

This study has several limitations. The sample analyzed in this study was selected in an attempt to study a spectrum of TMJ disc status, ranging from normal to disc displacement with deformation. The prevalence of ID identified in this study cannot be applied to the general female preorthodontic population. The results of this study are not directly comparable with previous investigations. The only other work that assessed the relationship between TMD and facial symmetry used patient complaints and clinical signs as well as transcranial radiography to assess joint status.[24] This study used objective MRI measurements to characterize the status of the TMJ articular disc and precisely measure internal derangement. The accuracy of MRI in diagnosing internal derangement ranges from 73% up to 90% or higher.[41,42]

We used multiple linear regression analysis to evaluate which regions of the craniofacial skeleton exhibit asymmetry that might explain the variability of TMJ ID. The results of the multiple regression analysis (Table 7) showed that the highest R^2 value was obtained for the (R − L) variable (0.20). This finding indicates that asymmetry of ramus height and deviation of ANS and the lower dental midline (InI) explained 20% of the difference in severity of TMJ ID between the right and the left sides. The low R^2 value for (R + L) (4%) could mean that the sum of structural changes within both TMJs was not associated with a greater amount of asymmetry. The group (R + L) contained patients with both unilateral and bilateral TMJ ID. The discrepancy between these two R^2 values suggests that asymmetry of the craniofacial structures could be associated with ‘‘asymmetry’’ of TMJ ID, regardless of the severity of changes in the TMJs.

Overall, vertical asymmetry showed a statistically significant difference with regard to TMJ ID as opposed to transverse asymmetry. This is consistent with previous studies that have shown reduced vertical posterior facial and ramus height in adolescent TMD patients[24] and in adults[43] on lateral cephalograms.

This was a cross-sectional investigation, and the time of onset of TMJ ID was not considered. Patients with TMJ ID should be reevaluated later, and the rate of change in TMJ ID severity should be compared with the rate of change in craniofacial asymmetry. The amount of asymmetry that was statistically significant between patients in different cluster groups did not appear to be of a magnitude that is clinically important. Follow-up investigation of adolescents with TMJ ID documented by MRI is required to establish the long-term relationship between TMJ ID and craniofacial asymmetry.

SUMMARY AND CONCLUSIONS

In this study, we investigated the association between TMJ internal derangement (disc displacement) and craniofacial asymmetry in 80 adolescent females prior to any orthodontic treatment. We found that females with bilateral TMJ ID have greater vertical mandibular asymmetry than do females with unilateral TMJ ID or females with normal TMJs. Other craniofacial regions did not exhibit significantly different asymmetry. These results indicate that a longitudinal evaluation is required to study whether further growth of female patients with disc displacement may result in clinically significant facial asymmetry.

ACKNOWLEDGMENTS

Supported by The Magnetic Resonance Center of Edmonton, Edmonton Diagnostic Imaging, The Rayburn McIntyre Fund for Dentistry and the TMD Investigation Unit, University of Alberta.

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