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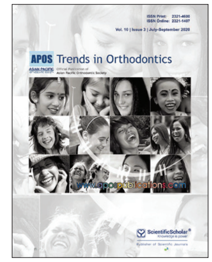

Original Article

Diagnosing mandibular asymmetry using posteroanterior cephalograms in patients with unilateral and bilateral degenerative joint disease

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Received : 26 May 2020
Accepted : 23 July 2020
Published : 18 September 2020

DOI
10.25259/APOS_79_2020

Quick Response Code:

ABSTRACT

Objectives: The purpose of this study was to evaluate the possible differences in facial asymmetry between bilateral degenerative joint disease (BDJD) and unilateral degenerative joint disease (UDJD) when compared to asymptomatic controls.

Materials and Methods: Posteroanterior cephalograms of 61 pre-orthodontic treatment patients (21 BDJD, 20 UDJD, and 20 controls) were evaluated (young adults, between 12 and 25 years of age) to investigate the inclination of the frontal occlusal plane (FOP) and frontal mandibular plane (FMP) to determine vertical asymmetry. Mandibular dental midline shift (DMS) and mandibular midline shift (MMS) were studied to determine transverse asymmetry. FOP, FMP, MMS, and DMS were compared pairwise between study groups, with multiple comparisons justified by Tukey–Kramer procedure. Correlation analyses were performed to evaluate the relationship between the measures. Mantel–Haenszel Chi-square test was used to evaluate the association between groups and symptom severity.

Results: The findings suggest that severity of the vertical mandibular displacement was associated with significant differences between BDJD and control patients, and between UDJD groups and control patients. However, they were no significant differences found between UDJD and BDJD patients, and this may be attributable to a different pattern of load on the ipsilateral and contralateral sides of the TMJ when they were compared to the controls. Moreover, the higher values of FOP and FMP correlated with the mandibular displacement being notably greater when the asymmetry was >3°. A similar tendency of a higher prevalence of mandibular displacement with a higher value of DMS and MMS was observed.

Conclusion: Clinical implications of this study apply to patients with asymmetry in vertical and transverse dimensions. These patients should be evaluated for dental, skeletal (condylar changes), and soft-tissue changes before orthodontic and/or orthognathic treatment planning.

Keywords: Mandibular asymmetry, Posteroanterior cephalogram, Bilateral and unilateral degenerative joint disease

INTRODUCTION

The Greek word *symmetria* which means "of like measure" is defined as correspondence in size, shape, and relative position of parts on opposite sides of a dividing line or median plane. Asymmetry is described as a lack of symmetry. When applying this to the human face, it exhibits an imbalance or disproportionality between the right and left sides. An average face illustrates an acceptable degree of asymmetry, which may be caused by a range of factors that affect the underlying skeletal structure or soft-tissue drape.[1]

A mild degree of asymmetry in the craniofacial region is common in humans,[2,3] including individuals with a normal facial appearance.[4,5] Clinically, various degrees of mandibular asymmetry are observed in many patients.[6] The importance of early diagnosis and the detection of progressive causative conditions is essential for the management of facial asymmetry.

Temporomandibular joint internal derangement (TMJ ID) is also widely reported to be associated with mandibular asymmetry.[7-10] Some authors have reported TMJ ID itself as a primary cause of growth disturbance, including mandibular asymmetry, and the data indicate that mandibular asymmetry can influence the shape and function of the TMJ and vice versa.[11,12]

The prevalence of a symptomatic side has been causally related to the degree of vertical asymmetry. Moreover, differences in bilateral TMJ morphology in patients with mandibular asymmetry have represented anatomic disorders and have been shown to predispose these patients to TMJ problems.[13]

A study by Buranastidporn *et al*. categorized patients with mandibular asymmetry into three grades, mild, moderate, and severe. For patients with mild mandibular asymmetry, the facial occlusal plane or frontal occlusal plane (FOP) and frontal mandibular plane (FMP) were <4°, with a tendency for ipsilateral TMJ ID. Patients with moderate mandibular asymmetry had the FOP and FMP angle of 4–7°, with a tendency for bilateral TMJ ID; and patients with severe mandibular asymmetry had the FOP and FMP angle >7°, with a tendency for contralateral TMJ ID.[14]

In a general orthodontic practice setting, patients presenting for initial screening and evaluation have records taken for comprehensive evaluation and treatment planning. These records typically include extra- and intraoral photographs, panoramic radiographs, lateral cephalograms, frontal cephalograms, and hand-wrist radiographs. Although panoramic radiographs are an excellent screening tool to identify gross osseous changes in the TMJ, it does not provide a thorough evaluation of the TMJ.

Magnetic resonance imaging (MRI) is considered to be the best method to assess suspected ID and for evaluating the soft-tissue structures of the TMJ (articular disc, synovial membrane, and lateral pterygoid muscle).[15] MRI could also detect the early signs of TMJ dysfunction, such as thickening of anterior or posterior band, rupture of retrodiscal tissue, changes in shape of the disc, and joint effusion.[16]

Computer tomography (CT) is considered a part of standard evaluation for bony elements and the adjacent soft tissues of the TMJ and is used for the diagnosis of fractures, degenerative changes, erosions, infection, invasion by tumor, as well as congenital anomalies.[17] CT scans, however, should be judiciously considered due to the high risk of radiation exposure, particularly in young patients.[18]

Posteroanterior (PA) cephalograms are widely used in radiographic evaluation of transverse asymmetry involving both skeletal and dentoalveolar components.[19]

We hypothesized that mandibular lateral displacement measured as mandibular symmetry on the PA cephalogram in the patients with unilateral degenerative joint disease (UDJD) is greater than in bilateral degenerative joint disease (BDJD) and significantly greater than that in the controls and that the degree of displacement will be significantly related to the cant of the FOP and the FMP, indicating the reduced vertical dimension of the posterior occlusal level and the ramus height on the side to which the mandible is displaced.

MATERIALS AND METHODS

Subjects

This study was a cross-sectional retrospective cephalometric study of young adult patient records, ages of 12–25 years old. The subjects were selected from the patients of the Department of Orthodontics and Dentofacial Orthopedics, Eastman Institute for Oral Health, University of Rochester, Rochester NY. Patient data were obtained from the Axium electronic patient record system and the Dolphin Imaging Software. The patient records (Axium electronic patient record) and data report were provided by the Axium team with complete records that included extraoral photographs, intraoral photographs, posteroanterior cephalogram, lateral cephalogram, and panoramic radiographs, with the teeth in centric occlusion position and with the Frankfort horizontal parallel to the floor. These records were obtained routinely before orthodontic treatment and were used for quantifying the asymmetry of each patient.

As the Eastman Institute for Oral Health is an educational institution, patients who undergo orthodontic treatment have signed consent for release and use of records for educational and research purposes. Patient records were accessed to extract data that were recorded in an Excel spreadsheet in a de-identified manner. Patient records were accessed from the Division of Orthodontics and Dentofacial Orthopedics, UR EIOH electronic database from January 1, 2009, to December 31, 2013.

In terms of inclusion and exclusion criteria, if there were incomplete records (no usable radiographs), they were excluded. In addition, patients with craniofacial anomalies were excluded from this study. Subjects were also excluded if they had a history of infection, tumors, rheumatoid disease, injuries to the TMJ, or other clinically significant pathology affecting the craniofacial region, or a congenital syndrome.

No consent was required as this study was a retrospective chart review with minimal risk to any one individual.

Moreover, all relevant data were already present in the patient's electronic dental record and the investigators had routine access to these dental records. No patient interaction occurred. A potential risk of breach of confidentiality was possible and to protect the breach of confidentiality, all information obtained were de-identified. Furthermore, there was no benefit to the research subjects.

In terms of privacy and the confidentiality of subjects and the research data, this was a minimum risk, retrospective, and chart review study; therefore, a HIPAA authorization waiver was obtained. The radiographs and radiographic measurements were collected from the charts by one investigator (Shaima Malik-SM) and entered in an Excel spreadsheet and stored on a password protected/encrypted computer located at Eastman Institute for Oral Health, Division of Orthodontics and Dentofacial Orthopedics. This study could not be conducted without the access to and use of protected health information (PHI). Data were accessed by study personnel only. Patients' record numbers were used to access and collect data and discarded on retrieval. Thus, PHI were de-identified and were not reused or disclosed to any other person or entity except, as required by law, or for the authorized oversight of the research study, or for other research for which the use of discloser of PHI was permitted by the HIPAA Privacy Rule. Data will be stored for 5 years after completion analysis.

A total of 61 young adult patients (45 females and 16 males) between 12 and 25 years of age were included in this study. Twenty-one patients were included in BDJD group, 20 in UDJD and 20 were controls.

Cephalometric radiography and analysis

Posterior-anterior cephalogram, lateral cephalogram, and panoramic radiographs obtained routinely before orthodontic treatment, with the mandible in intercuspal position, were collected for every patient.

All PA cephalograms were traced and the landmarks identified and investigated for asymmetry by one investigator (SM). All PA cephalograms were traced manually on 0.003″ thick matte acetate paper using a #3 pencil by one investigator (SM) after printing them from the Dolphin Imaging Software System (Dolphin Imaging and Management Solutions, 9200 Oakdale Ave. Suite 500, Chatsworth, CA 91311, U.S.A.).

The landmarks selected were based on previously published PA reproducibility study by Major *et al.*[20] A line passing through crista galli and anterior nasal spine (ANS) perpendicular to the line between the intersections of the greater wing of the sphenoid bone and the orbital margin was constructed first to represent the vertical reference plane, or the facial midline, as shown in [Figure 1].

FOP was defined and traced as the horizontal line that passed through the occlusal surface of the bilateral lower first molar, the angle was measured between the perpendicular line of the facial midline and the horizontal plane. Another line was traced connecting the right and left antegonial notches, the angle was measured between the horizontal plane and the perpendicular line of the facial midline and was defined as the FMP.

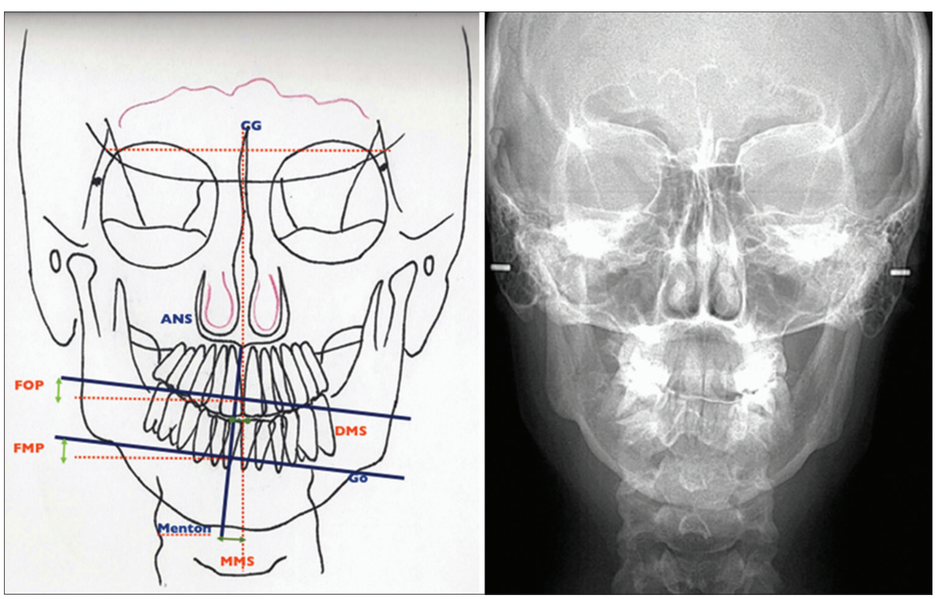

Figure 1: Tracing of posteroanterior cephalogram. Asymmetry was determined by frontal occlusal plane (FOP) and frontal mandibular plane angles (FMP) measured between the perpendicular line of the facial midline (vertical reference plane: Crista Galli and anterior nasal spine [ANS]). The angle between the facial midline and a line passing through ANS and Menton was defined as the degree of MMS. The distance in millimeters, between the facial midline and the midline of the mandibular incisors, was defined as the DMS.

The FOP and FMP were used to represent the deviation noted as asymmetry in the vertical dimension. Positive values for FOP and FMP indicated that these planes were inclined superiorly toward the short side. The angle between the facial midline and a line passing through ANS and Menton was defined as the degree of mandibular midline shift (MMS). The distance in millimeters, between the facial midline and the midline of the mandibular incisors, was defined as the dental midline shift (DMS). A DMS on the left and right side was termed as the absolute value for diagnostic criteria for transverse asymmetry.

The lateral cephalogram and panoramic radiographs were used with PA cephalograms to identify valid landmarks. The error of the method was determined by retracing each cephalogram on separate occasions, 2 weeks after the first tracing.[14]

Statistical analysis

Demographics (age, gender, and ethnicity) were tabulated by study group and compared using statistical tests using *t*-tests for continuous variables, Chi-square or Fisher's exact test for categorical variables, as shown in [Table 1].

FOP, FMP, DMS, and MMS measures were compared pairwise between the study groups, with multiple comparisons justified by Tukey–Kramer procedure.

Correlation analyses were performed to evaluate the relationship among the measures. Mantel–Haenszel Chi-square test was used to evaluate the association between group and symptom severity.

RESULTS

FOP, FMP, DMS, and MMS measures were compared pairwise between the study groups, with multiple comparisons using Tukey–Kramer procedure. Significant differences are found between normal and bilateral, normal and unilateral, but not between unilateral and bilateral patients [Table 2].

Correlation analyses were performed to evaluate the relationship among the measures. Mantel–Haenszel Chi-square test was used to evaluate the association between group and severity of the cant.

The outcome measures are significantly different between severity groups, with moderate/severe patients having higher values [Table 3].

All the measures were positively correlated, with Pearson correlation coefficients and p-values listed in Table 4.

The presence of TMJ ID was directly proportional to the values of FOP and FMP, with the mandibular displacement being notably higher when the asymmetry was >3° (i.e., the higher values associated with a higher prevalence of cant). A similar tendency of a higher prevalence of mandibular displacement with a higher value of DMS and MMS was observed [Table 3].

Mantel–Haenszel Chi-square test was used to evaluate the association between group and severity of mandibular displacement. There are significant differences in mandibular displacement and therefore asymmetry between normal and bilateral, normal and unilateral. However, no significant difference was detected between bilateral and unilateral groups [Tables 5-7].

DISCUSSION

Asymmetry of the mandible influences normal TMJ structure and function. Pathological conditions that affect the TMJ can manifest themselves as facial asymmetry, including congenital disorders such as hemifacial microsomia,[21,22] condylar hyperplasia,[23] ID,[24] rheumatoid arthritis,[25] and osteoarthritis.[26]

ID, that is, 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 TMJ disorders (TMD) have ID.[27,28]

Table 1: Table of demographics.

	Normal (*n*=20)	Bilateral (*n*=21)	Unilateral (*n*=20)	*P*-value
Age (mean±SD)	13.72±3.23	15.21±3.49	14.13±4.81	0.45
Gender male (%)	6 (30%)	5 (24%)	5 (25%)	0.89
Ethnicity				0.67
Caucasian (%)	11 (55%)	13 (62%)	11 (55%)	
AA (%)	3 (15%)	3 (14%)	3 (15%)	
Hispanic (%)	6 (30%)	4 (19%)	3 (15%)	
Asian (%)	0 (0%)	1 (5%)	3 (15%)	

Table 2: Pairwise comparisons with Tukey-Kramer justification: (Updated results after multiple comparison justification).

Variable	*P*-value (normal vs. bilateral)	*P*-value (normal vs. unilateral)	*P*-value (bilateral vs. unilateral)
FMP_Left	0.0049	0.0040	0.9931
FMP_Right	<0.0001	<0.0001	0.6922
FOP_Left	<0.0001	<0.0001	0.6344
FOP_Right	<0.0001	<0.0001	0.8858
DMS	0.0002	<0.0001	0.9499
MMS	<0.0001	<0.0001	0.89932

Table 3: Summary of measures by symptom severity.

Variable	Mild					Moderate/severe					*P*-value
	N	Mean	SD	Min.	Max.	N	Mean	SD	Min.	Max.	
FMP_Left	49	1.18	0.95	0	3	12	2.58	2.07	0	8	0.0407
FMP_Right	49	1.35	1.09	0	3	12	3.00	1.60	1	7	<0.0001
FOP_Left	49	1.10	0.94	0	3	12	3.50	1.57	1	6	0.0002
FOP_Right	49	1.24	1.05	0	3	12	3.75	1.29	2	6	<0.0001
DMS	49	1.22	1.03	0	3	12	2.50	1.62	1	6	0.0219
MMS	49	1.27	1.24	0	4	12	3.54	2.08	0	7	0.0031

Table 4: Correlation analysis between outcome variables. All the measures are positively correlated, with Pearson correlation coefficients and p-values listed in the table below.

Pearson correlation coefficients, *n*=61 Prob>|r| under H_0: Rho=0						
	FMP_Left	FMP_Right	FOP_Left	FOP_Right	DMS	MMS
FMP_Left FMP Left	1.00000	0.83581 <0.0001	0.55610 <0.0001	0.46143 0.0002	0.48742 <0.0001	0.48302 <0.0001
FMP_Right FMP Right		1.00000	0.55493 <0.0001	0.53429 <0.0001	0.55828 <0.0001	0.46520 0.0002
FOP_Left FOP Left			1.00000	0.80412 <0.0001	0.52596 <0.0001	0.62249 <0.0001
FOP_Right FOP Right				1.00000	0.51423 <0.0001	0.50197 <0.0001
DMS DMS					1.00000	0.42542 0.0006
MMS MMS						1.00000

Table 5: Table of groups based on severity of mandibular displacement.

Frequency Row Pct Col Pct	Table of groups based on severity of mandibular displacement				
	Group	Severity of mandibular displacement			
		Mild	Moderate	Severe	Total
	Normal	20 32.79 100.00 40.82	0 0.00 0.00 0.00	0 0.00 0.00 0.00	20
	Bilateral	14 22.95 66.67 28.57	6 9.84 28.57 54.55	1 1.64 4.76 100.00	21
	Unilateral	15 24 75.00 30.61	5 8.20 25.00 45.45	0 0.00 0.00 0.00	20 32.79
	Total	49 80.33	11 18.03	1 1.64	61 100

The prevalence of a symptomatic side has been a matter of controversy. Trpkova *et al*. evaluated frontal radiographs of female orthodontic patients with unilateral or bilateral temporomandibular joint disc displacement and compared them to female controls without disc displacement. They concluded that subjects with bilateral TMJ-ID had significantly greater asymmetry in the vertical position of the antigonion, and greater the disc displacement on one side, the shorter the ipsilateral ramus, resulting in significant asymmetry of the mandible.[24]

Tallents *et al*. conducted a study on 12 consecutive subjects presenting with facial asymmetry thought to represent unilateral condylar hyperplasia. However, half of these patients were found to have unilateral disc displacement that presented on the short side.[13] Another study by Fushima *et al*. reported that TMJ ID was more prevalent on the short side of the mandible.[9] One may argue that both these studies involved small sample size.

In contrast, Kurihara *et al*., in a study of 433 orthodontic patients, found that the symptoms were more frequently

Table 6: Table of groups based on severity of mandibular displacement.

Frequency Row Pct Col Pct	Table of groups based on severity of mandibular displacement				
	Group	Severity of mandibular displacement			
		Mild	Moderate	Severe	Total
	Normal	20 100.00 58.82	0 0.00 0.00	0 0.00 0.00	20
	Bilateral	14 66.67 41.18	6 28.57 100.00	1 4.76 100.00	21
	Total	34	6	1	41

Table 7: Table of groups based on severity of mandibular displacement.

Frequency Row Pct Col Pct	Table of groups based on severity of mandibular displacement			
	Group	Severity of mandibular displacement		
		Mild	Moderate	Total
	Normal	20 100.00 57.14	0 0.00 0.00	20
	Unilateral	15 75.00 42.86	5 25.00 100.00	20
	Total	35	5	40

bilateral. However, there was no clear evidence of how symptoms were observed on each side of the TMJ.[10]

The data from our retrospective study suggest that severity of the vertical mandibular displacement was associated with significant differences between BDJD and control patients, and between UDJD groups and control patients. However, they were no significant differences found between UDJD and BDJD patients, and this may be attributable to a different pattern of load on the ipsilateral and contralateral sides of the TMJ when they were compared to the controls. Moreover, the higher values of FOP and FMP correlated with the mandibular displacement being notably greater when the asymmetry was >3° (i.e., the higher values associated with a higher prevalence of symptoms). A similar tendency of a higher prevalence of mandibular displacement with a higher value of DMS and MMS was observed.

We acknowledge that not being able to confirm the diagnosis for TMJ ID or arthritic changes though MRI and CT scan may pose as a limitation to the study and further posteroanterior cephalometric studies would be valuable to confirm its use an alternative diagnostic tool for TMD diagnoses. We also think that future studies could benefit from increasing the sample size.

CONCLUSION

Overall, our findings suggest a relationship between vertical mandibular asymmetry in patients with temporomandibular degenerative joint disease, both UDJD and BDJD, when they were compared to controls and therefore recommend thorough dental, skeletal as soft-tissue evaluation including intraoral, extraoral, and radiographic examination of transverse asymmetry, by identifying condylar changes, antegonial notching, dental compensation, midline discrepancy, and comparing ramus heights, when planning an orthodontic or orthognathic surgical case.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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How to cite this article: Malik S, Tallents RH, Fishman LS. Diagnosing mandibular asymmetry using posteroanterior cephalograms in patients with unilateral and bilateral degenerative joint disease. APOS Trends Orthod 2020;10(3):171-7.