Mandibular skeletal and dental asymmetry in Class II subdivision malocclusions

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Mandibular symmetry was compared between a group of 28 subjects exhibiting Class II subdivision malocclusions and 30 subjects with Class I malocclusions who served as the control group. With submentovertex radiographs, symmetry was assessed by measuring the relative difference in spatial position of mandibular landmarks in both anteroposterior and transverse dimensions as determined by coordinate systems representing the cranial floor, mandible, and mandibular dentition. Only those variables representing the anteroposterior difference between right and left mandibular molar positions showed a statistically significant difference between the groups. Whether the position of the mandibular molars was measured relative to the cranial floor or within the mandible itself, the mandibular first molar was located more posteriorly on the Class II side of the subdivision malocclusion within a mandible that exhibited no other unusual asymmetry. (Am J Orthod Dentofac Orthop 1994;105:489-95.)

Class II subdivision malocclusions present difficulties in orthodontic treatment because of the asymmetric occlusal relationship and the obscurity of the underlying factors responsible for the malocclusion. A question arises as to whether the origin of the asymmetry is predominantly dentoalveolar, skeletal, or a combination thereof. Because subdivision cases account for approximately 50% of all Class II malocclusions,[1,2] the location and extent of asymmetry is of concern.

Several studies have attempted to find a relationship between occlusion and craniofacial asymmetry. Letzer and Kronman[3] found skeletal asymmetry to be independent of occlusion. The severity of facial asymmetry was also found to be independent of the severity of malocclusion by Hellman,[4] Fischer,[5] and Lundstrom.[6] Furthermore, these authors have reported some degree of facial asymmetry in persons with normal occlusion. A correlation between malocclusion and skull width asymmetry was found by Vasquez et al.[7] However, they acknowledged that their findings could have been coincidental because of their sample selection. In subjects of normal occlusions, Vig and Hewitt[8] and Shah and Joshi[9] reported the least amount of asymmetry in the dentoalveolar region.

Investigations into the location and extent of asymmetry have typically used lateral radiographs or posteroanterior (PA) radiographs. Recently, the submentovertex (SMV) radiograph has been suggested for analysis of asymmetry.[10-17] This head film allows for investigation of transverse and anteroposterior relationships. Methods for standardized SMV radiography have been described by Berger,[10] Gilbert,[11] and Nahoum et al.,[12] with each author noting the exceptional clarity of the mandible and the condyles.

Marmary et al.[13] suggested using the perpendicular bisector of the transverse distance between the foramina spinosum as a reliable cranial midline for SMV analysis. Nahoum et al.,[12] Cook,[14] Butow and Vander Walt,[15,16] and Forsberg et al.[17] have suggested various methods for the analysis of craniofacial asymmetry with SMV radiographs. However, most of these methods essentially assessed the asymmetry within persons, and were not used in group comparisons.

There is evidence that the mandible may account for some of the asymmetry in subdivision malocclusions.[18,19] The study by Williamson and Simmons[18] that used SMV films revealed a tendency toward a Class II buccal segment relationship on the shorter side of the mandible. Alavi et al.[19] using study models, lateral, and PA radiographs found that the anteroposterior asymmetry of Class II subdivision malocclusions was accounted for in a discriminant function analysis primarily

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0889-5406/94/$3.00 + 0 **8/1/40839**

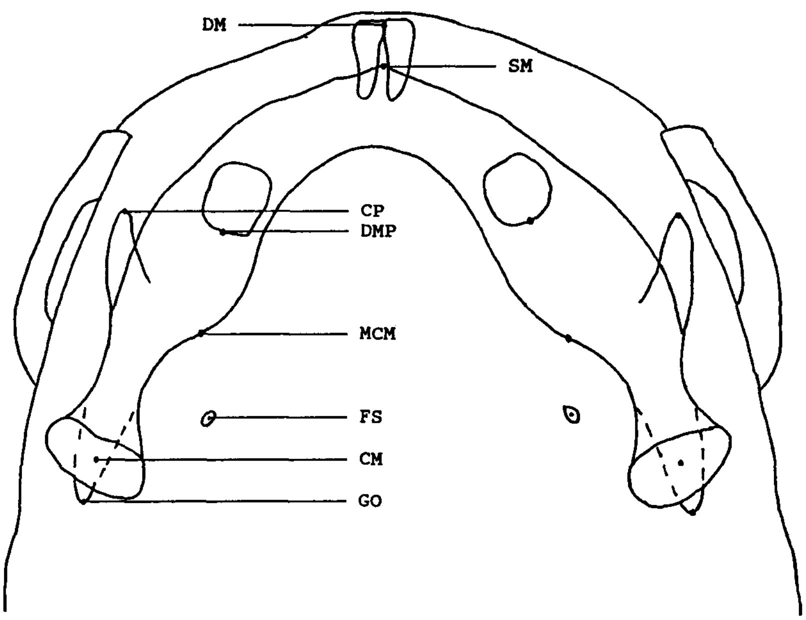

Fig. 1. Landmarks on SMV radiographs: *(FS)* Foramen spinosum, the geometric center of the outline of the foramen spinosum; *(CM)* condylar midpoint, determined by the point that bisects the line connecting the medial and lateral condylar poles; *(GO)* gonion point, the most posterior point of the gonial angle; *(CP)* coronoid process point, the most anterior point on the coronoid process; *(MCM)* medial contour of mandible, the most medial and posterior point on the medial outline of the body of the mandible; *(SM)* mandibular symphyseal midline, the most anterior point on the mandibular symphysis; *(DM)* mandibular dental midline, the point of contact between the crowns of the mandibular central incisors; *(DMP)* distal molar point, the midpoint on the distal outline of the lower first molar.

by the mandibular molar position. Whether the mandibular molar position was due to a skeletal asymmetry or a dentoalveolar asymmetry could not be determined.

If we hypothesize that Class II subdivision malocclusions are partially attributable to asymmetry of the mandible, then a comparison between Class II subdivision malocclusions and those with Class I malocclusions should reveal significant differences in mandibular symmetry. The purpose of this study was therefore to ascertain whether Class II subdivision malocclusions could be explained by differences in mandibular skeletal and/or dental asymmetry.

MATERIALS AND METHODS

Submentovertex (SMV) radiographs of 58 patients were obtained from the pretreatment records of an orthodontist in private practice. The SMV radiographs had been taken with a Quint Sectograph (Quint X-Ray Co., Inc., Los Angeles, Calif.) as part of the horizontally corrected tomograms of the temporomandibular joints routinely taken on all adult patients. The sample was divided into two groups based on the malocclusion present. The study group consisted of 28 subjects exhibiting Class II subdivision malocclusions (full Class I molar relationship on one side and a Class II molar relationship on the opposite side), whereas 30 subjects with Class I malocclusions comprised the control group. The mean age of the study group was 28.4 years (standard deviation 11.71 years), and for the control group 24.9 years (standard deviation 9.27 years). There were 22 females in each group.

The subjects were selected according to the following additional criteria: (1) A pretreatment submentovertex film of good quality was available for each subject. (2) No history of previous orthodontic treatment. (3) Availability of dental models of good quality. (4) No lateral functional mandibular shifts on closure as revealed in the clinical history. (5) Absence of history of facial trauma or medical conditions that could have affected the growth of the mandible. (6) Full dentition in maxillary and mandibular arches through the first permanent molars.

Submentovertex radiographic landmarks

On the SMV films, the outlines of the mandible and the foramina spinosum were traced onto matte acetate. The tracings included the condyles, coronoid processes, gonial angles, first molars, and central incisors (Fig. 1). The landmarks were digitized with the OLI system (Orthodontic Logic Inc., Kansas City, Mo.), with a film magnification of 17.7%, for subsequent analysis (see Fig. 1 for definition of landmarks).

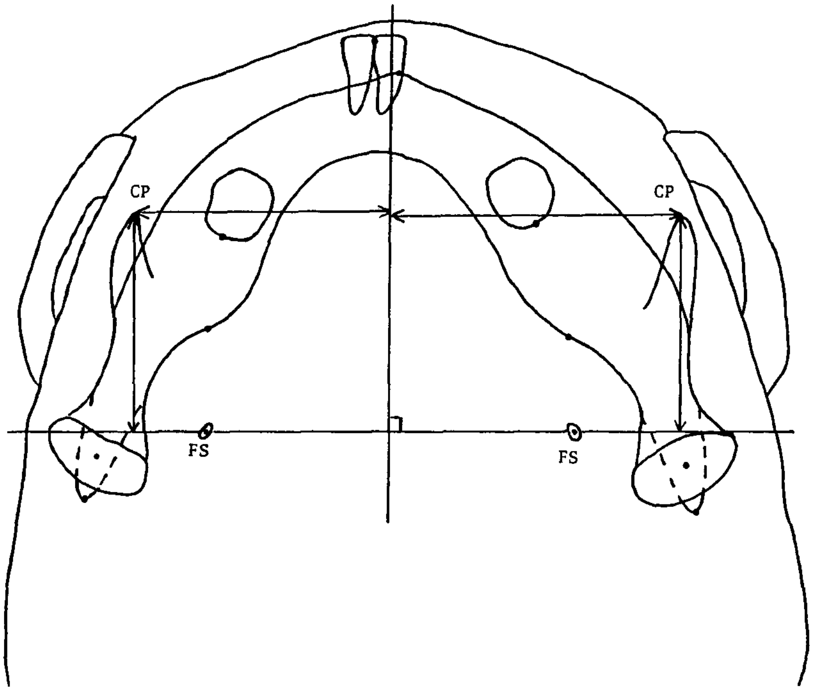

Fig. 2. Cranial floor coordinate system, with spatial position of coronoid process point *(CP)* illustrated.

Assessment of asymmetry

Mandibular asymmetry was assessed at three levels through coordinate systems representing the cranial floor, the mandible, and the mandibular dentition. The first related both skeletal and dental components of the mandible to the cranial floor. Secondly, mandibular skeletal and dental asymmetry was assessed relative to the mandibular condyles. Lastly, the symmetry of the mandibular dentition was related to the lower molars. Thus asymmetry of the mandible was determined through a hierarchy of asymmetry descriptions.

Mandibular asymmetry relative to cranial floor. The cranial floor coordinate system consisted of the line connecting the foramina spinosum (FS) landmarks and its perpendicular bisector. Mandibular asymmetry was assessed by the differences between the right and the left bilateral landmarks in both anteroposterior and transverse dimensions, and in the transverse dimension for the mandibular symphyseal (SM) and dental midline (DM) points (Fig. 2). This portion of the analysis generated a total of 12 measurements per subject.

Mandibular asymmetry assessed within the mandible. A mandibular skeletal coordinate system was generated by the line connecting right and left condylar midpoints (CM) and its perpendicular bisector. In a similar manner to that of the cranial reference system, mandibular asymmetry was assessed by the differences between the right and the left bilateral mandibular skeletal and dental landmarks (GO, CP, MCM, and DMP) in both anteroposterior and transverse dimensions to the mandibular skeletal coordinate system; the distance of the midline landmarks (SM and DM) in a transverse dimension was also measured. This produced 10 measurements per subject (Fig. 3).

In addition, a dental coordinate system was derived from the line connecting right and left distal molar points (DMP) and its perpendicular bisector. The distance of the dental midline landmark (DM) was measured in a transverse dimension (Fig. 3).

Additional measurements. The relative parallelism of the three coordinate systems was determined by angular measurements between their respective abscissae, generating three measurements per subject.

To detect any length differences between the two sides of the mandible in a more direct manner, the difference between the left and the right distances from the condylar midpoint to the symphyseal midline was calculated. In addition, the difference between the right and the left distances from the condylar midpoint to the medial contour of the mandible was used to approximate the effective horizontal length of the ramus. With the inclusion of the above five measurements, there was a total of 28 variables.

Method error. Ten radiographs were selected at random to determine tracing and measurement error. These radiographs were traced on two separate occasions, and then digitized with correction for magnification. The mean difference of each variable between the successive tracings were compared with paired *t* tests. No significant differences were found between the two sets of measurements (*alpha* = 0.05). In

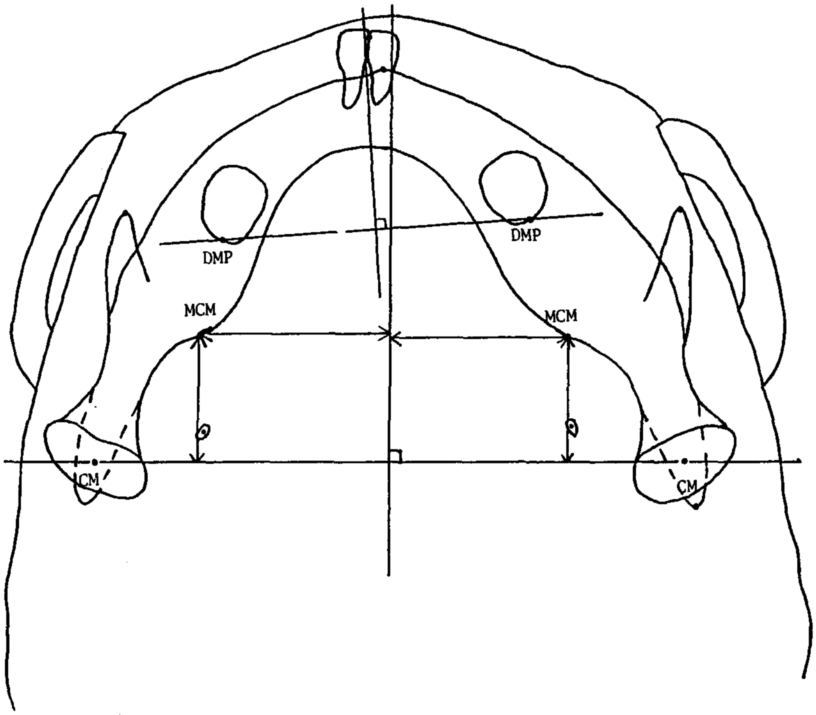

Fig. 3. Mandibular skeletal and dental coordinate systems. Spatial position of medial contour of the mandible *(MCM)* to mandibular skeletal coordinate system is illustrated.

addition, the accuracy of SMV measurements was tested by comparing the dental midline deviation (DM) relative to the dental coordinate system of 10 SMV films with the corresponding measurement obtained from the dental models. Points DM and DMP were transferred from the models onto paper using dividers. A *t* test revealed no significant difference between the midline measurements (mean difference 0.275 mm; standard deviation 1.17 mm; *p* value 0.474).

As reported by Gilbert,[11] a comparison of successive SMV films showed a high degree of accuracy in transverse measurements, but significant error in anteroposterior measurements. However, the assessment of anteroposterior asymmetry, as used in this study, should not be affected by any reproducible inaccuracies associated in this dimension of SMV films. Although the magnification in the anteroposterior dimension may vary between successive films, the amount of anteroposterior distortion in any single film would be expected to pertain similarly for both the left and the right sides of the film.

Data analysis. The 28 variables from each group were compared by using independent *t* tests at a significance level (α) of 0.05. To control for type I error when performing multiple *t* tests on correlated variables, a Bonferroni adjustment was made in the α-level whereby a significance level of 0.05 was maintained when a *p* value less than 0.0018 ($0.05 \div 28$) was obtained for any variable.

RESULTS

The mean and standard deviation for each variable in both groups are reported along with the results of the *t* tests in Tables I to III. For the study group, the data were analyzed whereby the Class II side of the malocclusion was always designated as the left side. For those variables representing differences between bilateral landmarks, a negative mean value indicates a smaller average measurement on the left side than the right side. A negative mean value for midline landmarks indicates a mean midline deviation to the left relative to the reference system. Downward and backward angular measurements are recorded as positive values.

Table I provides the *t* tests of variables measured relative to the cranial coordinate system. Only the variable representing the anteroposterior difference between right and left mandibular molar positions (DMP) shows a statistically significant difference between the groups. All other skeletal and dental variables of asymmetry relative to the cranial floor fail to show any significant difference (Bonferroni correction in $\alpha = 0.05$ maintained when $p < 0.0018$).

The *t* test results of the variables relative to the mandibular skeletal and dental coordinate systems are

Table I. *t* tests of variables relative to cranial floor coordinate system (in millimeters)

Cranial floor coordinate system	*Control group*		*Study group*		
	Mean	*SD*	*Mean*	*SD*	*p value*
Anteroposterior dimension					
Skeletal landmarks					
CM	0.71	1.42	0.24	1.68	0.257
GO	0.22	1.74	1.06	2.43	0.142
CP	−0.59	2.08	0.00	3.52	0.439
MCM	−0.05	1.71	−0.77	2.40	0.192
Dental landmark					
DMP	−0.61	1.07	−2.11	1.79	0.0003*
Transverse dimension					
Skeletal landmarks					
CM	−0.03	1.86	−0.21	2.08	0.735
GO	0.59	2.41	−0.73	2.44	0.044
CP	0.46	2.81	−0.68	2.83	0.132
MCM	0.14	3.40	−0.54	2.86	0.414
SM	−0.51	2.08	−0.46	2.62	0.937
Dental landmarks					
DMP	0.92	4.00	0.37	4.27	0.617
DM	−0.60	2.75	−0.99	2.95	0.603

*Statistically significant (Bonferoni correction $\alpha = 0.0018$).

listed in Table II. There was a significant difference between the groups in anteroposterior positioning of the left and right mandibular molars relative to the intercondylar line (DMP). The mean of −1.90 mm for the study group indicates that the perpendicular anteroposterior distance from the intercondylar line to the mandibular molar on the Class II side is almost 2 mm less than that on the Class I side.

The between groups *t* test results that used the angular variables are given in Table III. Two of the three differences are found to be statistically significant. These variables measure the angle formed by the line connecting the distal molar points to each of the lines connecting the FS and the condylar midpoints.

No significant differences were found between the left and right side measurements of the mandible. No group differences in total mandibular length and ramal length were detected (Table III).

DISCUSSION

Whether the position of the mandibular molars is measured relative to the cranial floor or to the mandibular condyles, the results of this study indicate that the mandibular first molar is located more posteriorly on the Class II side of the subdivision malocclusion within a mandible that exhibits no other unusual asymmetry. However, it should be noted that this study was limited to the mandible, as maxillary submentovertex landmarks are difficult to locate. Any differences found in mandibular asymmetry certainly would not exclude the possibility that maxillary dentoalveolar or skeletal asymmetry may also contribute to subdivision malocclusions.

As related to the cranial floor, there were no group differences in mandibular skeletal symmetry or in anteroposterior relationships of the mandible. This does not support the supposition that Class II subdivision malocclusions result from a difference in anteroposterior position of the "sides" of the mandible relative to the cranium. Rather, the relationship of the mandible to the cranial floor in subdivision malocclusions appears to be similar to that of Class I malocclusions. Only the anteroposterior difference in molar position was found to be significant between the groups. This indicates that the entire mandibular dentition in subdivision cases may be considered as being "rotated" within a symmetrical mandible. Accepting this concept, a similar significant group difference would be expected in the deviation of the mandibular dental midline relative to the cranial floor. A possible explanation for the lack of such a finding could be that all subjects selected for the study had malocclusions with various amounts of mandibular anterior crowding.

Several investigations[20-22] have shown mandibular

Table II. *t* tests of variables relative to mandibular skeletal and dental coordinate systems (in millimeters)

Mandibular coordinate system	Control group		Study group		p value
	Mean	SD	Mean	SD	
Skeletal coordinate system					
Anteroposterior dimension					
Skeletal landmarks					
GO	−0.19	1.62	0.48	1.79	0.143
CP	0.05	1.85	0.38	2.90	0.610
MCM	0.40	1.49	−0.55	2.21	0.059
Dental landmark					
DMP	−0.27	0.99	−1.90	1.37	0.0001*
Transverse dimension					
Skeletal landmarks					
GO	0.72	2.31	−0.50	2.38	0.052
CP	0.02	2.52	−0.73	2.53	0.262
MCM	−0.06	3.26	−0.51	2.85	0.574
SM	−0.07	2.24	−0.31	2.69	0.714
Dental landmarks					
DMP	0.40	3.82	0.24	4.26	0.883
DM	−0.10	2.63	−0.81	2.99	0.342
Dental coordinate system					
Tranverse dimension					
Dental landmark					
DM	0.27	0.97	0.61	1.30	0.265

*Statistically significant (Bonferoni correction α = 0.0018).

Table III. *t* tests of additional variables

Variable	Control group		Study group		p value
	Mean	SD	Mean	SD	
Angular measurement between abscissae of following coordinate systems					
Cranial-skeletal	0.39	0.75	0.21	1.01	0.432
Cranial-dental	0.68	1.16	2.32	1.86	0.0002*
Skeletal-dental	0.28	1.13	2.09	1.41	0.0001*
Left minus right measurements of the distance in mm					
CM-MCM	0.25	2.92	−0.06	3.10	0.693
CM-SM	−0.11	2.65	−0.42	3.33	0.700

*Statistically significant (Bonferoni correction α = 0.0018).

asymmetries resulting from an event that disrupted condylar growth. Even in the cases where arrest of condylar growth was temporary, the altered facial pattern did not show any compensatory growth that would help reduce the asymmetry. When condylar growth was affected unilaterally, all investigators found a shorter ramus on the affected side with a concurrent deviation of the chin and canting of the occlusal plane. This may lead one to conjecture that subdivision malocclusions possibly arise from a similar, although milder, form of unilateral condylar growth hypoplasia, which would result in the subdivision side of the mandible being shorter in length than the opposite side. However, the present study failed to demonstrate any significant group difference between the lengths of the left and right sides of the mandible.

Furthermore, all measurements relative to the condylar midpoints indicate that no group difference in mandibular skeletal morphology could be detected. The left and right sides of the mandible in Class II subdivision malocclusions do not differ significantly from Class I malocclusions in either transverse or anteroposterior asymmetry. However, the difference between the right and left molars in the anteroposterior dimension was significant between groups, with the subdivision group exhibiting a distal positioning of the mandibular molar of almost 2 mm on the Class II side.

These findings suggest that orthodontic treatment of Class II subdivision malocclusions should probably address the anteroposterior asymmetry of the mandibular buccal segments. Although the mandibular canine was not included in this study, a valid assumption would be the forward transference of the molars' anteroposterior asymmetry to the canines in the absence of crowding in the buccal segments. Depending on the position, inclination, and crowding of the lower incisors, a suitable treatment objective for the attainment of canine anteroposterior symmetry could then be appraised. It would be necessary to consider how canine anteroposterior symmetry could be achieved, and how the mechanics would impact the lower incisors.

There are different methods for achieving mandibular symmetry in the anteroposterior dimension. Unilateral mechanics restricted to the mandibular arch and directed at bringing only one buccal segment posteriorly or anteriorly are difficult to accomplish. Interarch mechanics such as Class II or Class III elastics may affect the maxillary arch as well. Wertz[23] and Cheney[24,25] described asymmetric extraction strategies affecting the mandibular arch in the treatment of Class II subdivision malocclusions. In these strategies, the mandibular extractions were either the removal of a premolar on the Class I side, or the removal of the first premolar on the Class I side and the second premolar on the Class II side. Both of these extraction patterns would assist in attaining symmetrical canines as a difference in anchorage between the left and the right canine is created. In the absence of anteroposterior asymmetry in the maxillary arch and if minimal or no crowding exists in the arches, serious consideration should be given to accepting asymmetry in the occlusion, including a deviated mandibular midline, and to treating to an ideal overjet and overbite as the primary objectives. All of these different techniques need to be considered when planning the treatment of Class II subdivision malocclusions.

This study supports the findings of Alavi et al.[19] of a relative anteroposterior difference in spatial positioning of mandibular molars in Class II subdivision malocclusions. In addition, this study has found that the mandible in Class II subdivision malocclusions exhibits no unusual skeletal positioning or skeletal asymmetry. Only the mandibular dentition was found to be asymmetric, resulting in a relative distal positioning of the lower first molar on the Class II side.

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