Aspects of mandibular morphology, with specific reference to the antegonial notch and the curve of Spee

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The purpose of this investigation was to determine whether particular metrical traits of the mandibular antegonial notches are associated with specific mandibular growth patterns, and also with the mean depth of the curve of Spee. Thirty pre-treatment lateral cephalometric radiographs belonging to a randomly selected group of patients treated in the orthodontic clinic at the SUNY at Buffalo were digitized. The surface areas of the mandibular antegonial notches, as well as some sagittal facial dimensions were measured on each radiograph. The curve of Spee was measured directly from the pre-treatment mandibular study cast of each patient included in this study. An analysis of variance showed no statistically significant difference (p<0.01) between the measurements recorded by the two examiners who conducted this study. The results of this study showed a statistically significant positive correlation between the surface areas of the antegonial notches and the lower anterior facial heights (r= 0.87, P<0.001). At the same time a statistically significant negative correlation was found between the surface areas of the antegonial notches and the lengths of the mandibular bodies (r= -0.9, P<0.001). A significant negative statistical relationship was shown to exist between the lower anterior facial heights and the lengths of the corresponding mandibular bodies, and also between the depths of the curves of Spee and the surface area of the respective antegonial notches (r= -0.85, P< 0.002). The results of this study indicate that an increase in the areas of the antegonial notches is associated with a tendency for greater vertical growth of the mandible. The results further suggest that the depth of the curve of Spee and the length of the mandibular body are decreased when there is an increase in the surface areas of the antegonial notches.

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INTRODUCTION

The ability to predict the magnitude and direction of mandibular growth would be beneficial in orthodontic diagnosis and in the treatment planning of growing patients. It has been documented that the mandible descends in a downward and forward direction.[1-5] The mandible has also been shown to rotate during growth[6-9] and that as a result of this rotation; it can develop either a protrusive, or retrusive position relative to the anterior cranial base and to the maxilla.[10]

In implant studies, Björk showed that numerous anatomical structures could be associated with mandibular rotation. Accordingly, in those mandibles with predominantly vertical growth patterns apposition occurs below the symphyses, which results in an overall concavity of the inferior border. At the same time mandibles that rotate backward and downward during growth, usually exhibit pronounced bone apposition beneath the gonial angles with excessive resorption posterior to the bony symphyses. Thus, excessive vertical mandibular growth results in bilateral cranially directed curvatures, or antegonial notches, of the inferior border of the mandible.[4,8,9,11]

The growth potential of mandibles with pronounced antegonial notching is reduced, whereas, generally, mandibles with straight inferior borders tend to be longer than those that have deep notches. The mean total anterior facial height of subjects with straight (un-notched), mandibular inferior borders was smaller than that of subjects with deep antegonial notches.[12,13] Also, the presence of prominent mandibular antegonial notches is frequently noted in subjects who have disturbed, or arrested, mandibular condylar growth.[9,14-18] In cases of unilateral condylar hypoplasia,

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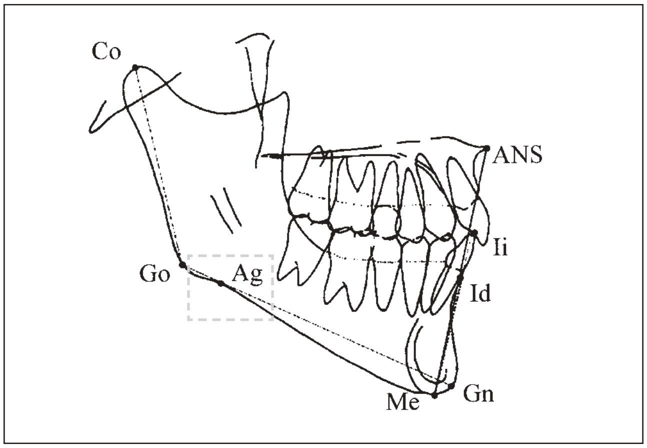

Figure 1. Landmarks and planes used on the digitized cephalometric radiograph.

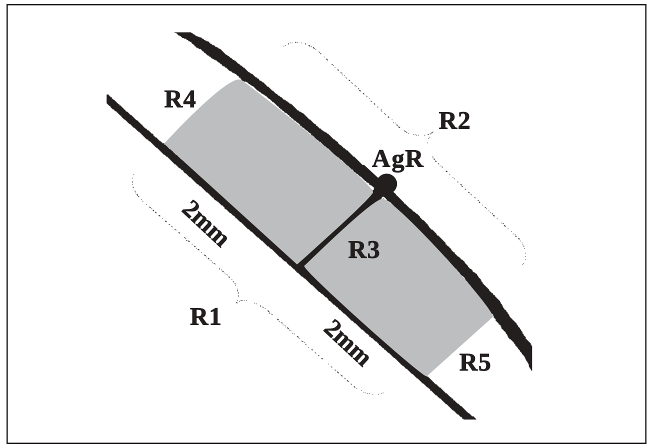

Figure 2. Enlarged image of the mandibular antegonial notch.

Figure 3. Measuring the depth of curve of Spee using the caliper.

marked mandibular notching develops mainly on the affected side.[14,17-19]

Several hypotheses have been proposed to explain the functional significance of the curve of Spee in natural, and orthodontically treated dentitions.[20-23] Explanations for the presence of a curve of Spee in natural dentitions include those that state that such a curve may make it possible for these dentitions to offer a greater resistance to the forces of mastication. This suggested resistance to the forces of occlusion is said to enhance the stability of the dentition and to make it less subject to physiologic changes.

Osborn proposed that the curve of Spee increases the crush to shear ratio of the chewing forces in the molar region, while another explanation links the existence of such a curve with mandibular function during protrusive jaw movements.[24] The curve of Spee along with condylar guidance, incisal guidance, molar cusp heights and the plane of occlusion all make it possible to establish a mutually protected occlusion.[23-25]

An exaggerated curve of Spee has been associated with fan-shaped incisors and an excessive overbite.[28] According to Root[29] Fidler, Artun, Joondeph and Little[30], when a skeletal open bite is not present, the curve of Spee in Class II malocclusions is deeper than in other malocclusions. While several theories have been proposed to explain the presence of a curve of Spee in natural dentitions, its role during normal mandibular function has been questioned.

Many studies have attempted to explain the presence of a deep curve of Spee, and specifically, in relationship to other common occlusal findings.[25,26,31] Thus, it has been proposed that an imbalance between the anterior, and the posterior, components of the occlusal force, can cause the lower incisors to over-erupt, the bicuspids to infra-erupt, and the lower molars to be mesially inclined.[27]

The aim of this study was to determine whether the morphology of the antegonial notch could be linked to facial metrical characters, and to look for a relationship between the morphology of the antegonial notch and the depth of curve of Spee.

MATERIALS AND METHODS

The randomly selected pre-treatment orthodontic records of thirty-six adolescent patients attending the Orthodontic Department of the SUNY at Buffalo formed the basis of this study. The frontal cephalometric radiographs of these patients were used to exclude the records of six subjects, who displayed obvious facial asymmetry, from the study. The remaining thirty pre-treatment lateral cephalometric radiographs were digitized with the JOE32® computer program (RMO®). All of the radiographs included in this study were exposed with the same radiographic setup, which produced a mean 5% (range = 2.5% to 5.0%) linear enlargement, of objects placed between one, and six inches from the film plane. Two examiners used a standardized technique to digitize the chosen radiographs and to identify specific craniofacial structures and landmarks as seen on the lateral cephalometric radiographs, Figure 1. The following lines were drawn and measured: ANS-Me, Id-Me, Ii-Me,

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Co-Go and Go-Gn. The results obtained by the two examiners were subjected to statistical evaluation to test for intra-, and inter-operator errors.

Since the study utilized lateral cephalometric radiographs, it was not possible to identify both antegonial notches clearly on five of the thirty radiographs used in the study. On these five radiographs only a single well-defined gonial notch was measured, while the bilateral notches were measured on the rest of the radiographs and the average of the right and left notch of each case was utilized for statistical analysis and comparison was taken. Digital optical images of the selected antegonial notches were produced with a Nikon® stereomicroscope at 2x magnification.

A tangential line (R1) to the inferior border of the mandible was constructed and a perpendicular (R3) from Ag to the tangent was drawn. The surface area of each antegonial notch was limited mesially and distally by the lines R4 and R5 that were constructed 2mm away from, and parallel to line R3. The limiting lines extended from the tangential line (R1) to the outline of the antegonial notch. The length of the outlines of the antegonial notch between the limiting lines was termed R2. The surface area of each notch was determined and measured with the image-pro program®. The surface area that was measured is the shaded area shown in Figure 2.

The corresponding pre-treatment study model casts, of the thirty lateral cephalometric radiographs included in this study, were used in the next part of this research project. Because some of the patients in this study did not have second molars fully erupted at the time of the measurement, the curve of Spee was measured to the first molars only. The curve of Spee in this study was measured from a flat plane that linked the center of the incisal edge of the mandibular central incisor anteriorly to the disto-buccal cusp tip of the first molar posteriorly.[32] The depth of the curve was measured on each side of the mandibular arch as being the vertical distance from the buccal cusp tip, of the most infra-occluded premolar, to the occlusal plane previously described.[32] The curves of Spee were measured with a standard palatometer (GPM®, Switzerland) Figure 3. The palatometer consists of three moving parts. The two horizontal arms can be adjusted for length in order to reference the occlusal plane that was previously described. The third arm, which is attached at 90° to the horizontal reference arms, consists of ruler with a 0.50 mm scale. The pointed tip of the ruler can be moved to measure the vertical distance from the occlusal plane to the buccal cusp tip of the most infra-occluded premolar. The curves of Spee were measured on the left, and the right, sides of each set of mandibular models, and the sets of measurements obtained were compared statistically with a paired t-test. The results indicated that there was no significant statistical difference ($p>0.01$) between these sets of measurements for each of the 30 cases studied. Therefore, the average of the right and left curves of Spee for each case was utilized for statistical analysis and comparison.

RESULTS

An analysis of variance did not disclose statistically significant ($p<0.01$) intra-, or inter-operator, differences in the measurements made by the two examiners. The intraclass correlation coefficient indicated that the reliability of the measurements made in this study were statistically significant ($r=0.99$).

Statistical analysis of the data disclosed the presence of statistically significant associations between the mean values of the surface area of the mandibular antegonial notches and some of the mean values of the facial metrical characters used in this study. There was a statistically significant positive correlation between the surface area measurement of the antegonial notches and the mean measurement of the lower facial height (ANS-Me), ($r=0.87$, $p<0.001$). There was also a significant statistical negative correlation between the mean values of the antegonial notches surface area and the mean measurements of the body of the mandible (Go-Gn), ($r=-0.9$, $p<0.001$). The mean depth of the curve of Spee measurements was found to have a significant correlation in the negative direction (Table1) with the measurements of the antegonial notches, ($r= -0.85$, $p<0.002$).

There were no statistically significant correlations between the mean values of the surface area of the notches and the following mean measurements: Id-Me ($r= 0.25$, $p=0.21$), Ii-Me ($r=0.2$, $p= 0.12$), and Co-Go ($r=0.3$, $p=0.06$).

Table 1. Measurements in millimeters with correlation coefficient between the mandibular antegonial notch (Ag) surface area and the following facial dimensions: ANS-Me, Go-Gn, Curve of Spee, Id-Me, Ii-Me, and Co-Go.

	Mean ± sd	Correlation Coefficient	P- value
Ag Surface Area	6.38 ± 3.91		
ANS-ME	68.07 ± 9.3	0.87	<0.001
Go- GN	59.53 ± 7.34	- 0.9	<0.001
Curve of Spee	3.55 ± 1.15	- 0.85	<0.002
Id- Me	28.82 ± 5.01	0.25	0.21
Ii- Me	39.73 ± 4.52	0.2	0.12
Co-Go	57.3 ± 7.33	0.3	0.06

DISCUSSION

Sicher,[33] in an address to the orthodontists during meeting of the American Association of Orthodontists in 1946, stated that orthodontists are “the ones who not only talk about growth of the human body, but try to do something about it.” Fifty years later, the prediction of facial growth, and facial growth modification are still

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controversial topics among orthodontists. In growing orthodontic patients the shape of the mandible has a direct bearing on the specific treatment modality chosen and also on the resultant facial aesthetic appearance.

The mandible is a unique bone and some care must be taken in adopting for the mandible findings, which have been proven in other bones. The mandible is the only single midline bone in the body, which is activated by a bilateral set of muscles. Furthermore, the sensory and functional relationships of the dentition and the bilateral temporomandibular joints are unique to this bone.[1]

Although the mandible is a single bone in adults, it is developmentally and functionally divided into several skeletal subunits.[34,35] The basal bone of the mandibular body forms one unit, to which are attached the alveolar, coronoid, angular, condylar process and the chin. The growth of each of these skeletal subunits, is influenced by the teeth and muscles that provide the functional matrix of the lower jaw.[35]

The ultimate shape of a fully-grown mandible is the result of complex interaction of the growth determinants and the functional environment that control the lower jaw.[3,6,9,14] The antegonial notch lies at the junction of the body, and the ramus, of the mandible and in this strategic position its shape is probably a good indicator of how the mandibular grew, or perhaps more essentially, will grow. It has been documented that when the lower border of the mandible is relatively flat, it grows forward and, that when the lower border of the mandible represented by the antegonial notch is concave the mandible grows downward.[4,8] Some studies show that when the condylar growth fails to contribute to the lowering of the mandible, the masseter and the medial pterygoid, by continued growth, cause the bone in the region of the angle to grow downward producing antegonial notching.[18]

Animal studies show that the presence of the superficial masseter, and or the medial pterygoid, muscles are necessary for the development of the angular process of the mandible.[14,36] When an imbalance occurs between the masseter and the medial pterygoid muscles and the suprahyoid muscles, opposing functions will cause the mandible in the antegonial region to undergo specific changes. The resorption that normally occurs ahead of the gonial angle does not occur. Rather, a relative tension is generated between the bony mandibular angle and the muscles sling in which it is suspended such that bone deposition occurs in the area under the angle posterior to the notch.[3,16-18,37]

The present pilot study was undertaken to gain some basic insight into the association between the shape of the gonial notch and the vertical and sagittal growth potential of the mandible. The study indicated that when an antegonial notch surface area is relatively large, the anterior lower facial height (ANS-Me) tends to be relatively long. The study also indicated that in individuals with larger antegonial notches, the mandible corpus tends to be shorter in length. The study further suggested that a close negative correlation exists between the anterior lower facial height and the length of the mandibular corpus.

The curve of Spee is closely associated with mandibular function, and it may be affected by the direction of the mandible growth.[23,25] It has been proposed that an imbalance between the anterior, and the posterior, components of the occlusal force, can cause the dentition to have specific changes.[27] This study indicates that there was a statistically significant negative relationship between the size of the antegonial notch and the depth of curve of Spee, ($r = -0.85$, $p < 0.002$).

CONCLUSION

1. The morphological patterns of the mandible are associated with the morphology of the mandibular antegonial notches as seen on the lateral cephalometric radiograph.
2. Subjects with increased surface area notch had an increased lower anterior facial height, decreased mandibular body length, and decreased curve of Spee depth as seen on the lateral cephalometric radiograph.
3. In this sample, when the lower anterior facial height is increased, the length of the mandibular corpus is decreased as seen on the lateral cephalometric radiograph.
4. There were no statistically significant correlations between the surface area measurements of the notch and: Id-Me, Ii-Me and Co-Go.

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