Changes in condylar and mandibular angles with growth and aging

Shigeo Osato and Ken Hiratsuka

Department of Oral Anatomy, School of Dentistry at Tokyo,
The Nippon Dental University
(Chief: Assoc. prof. Shigeo Osato)
1-9-20 Fujimi, Chiyoda-ku, Tokyo, 102, Japan

Accepted for publication: November 18, 1993

Key words: condylar angle/mandibular angle/gonial angle/antegonial angle/mandible

Abstract: In accordance with Hellman’s classification of developmental stages, a total of 278 pieces of the right and left sides from 140 dried mandibles of Asian Indians were classified into four groups—IIA, IVA, IVC • VA and VIIIEJ—and analyzed goniometrically using standard lateral photographs. By doing this, changes of the condylar and mandibular angles with growth and aging were examined.

The condylar angle is defined here as the angle formed by two tangents to the inferior border of the body of the mandible and the posterior border of the ramus, and the mandibular angle as the region of the angular junction where the inferior border of the body of the mandible and the posterior border of the ramus come together and also the angle of the contour formed by that region. Therefore, both angles have to be measured separately.

The condylar angle decreased by 5°~12° throughout the growth period and increased by 4° due to aging. The mandibular angle was expressed in two angles for the gonial and antegonial angles. The gonial and antegonial angles decreased by 6° during the first half of the growth period. Thereafter, the former increased by 4° only due to aging and the latter did not show any significant variations with growth or aging. It is suggested that the lower and posterior border of the ramus and the backward and inferior border of the body of the mandible contouring the mandibular angle change differently but are closely related with the functional changes in the muscles of mastication due to eruption as well as the loss of permanent teeth.

抄録：Hellman’s developmental stage（IIA, IVA, IVC・VA および VIIIEJ）に準じ、140個のインド人属下顎骨の左右側のうち 278 個を 4 群に分け、その外側面観写真の角度分析を行い、下顎枝角と下顎角の成長変化および加齢変化を検討した。

下顎枝角とは下顎体下線および下顎枝後綫の接線でつくれられた角度で、下顎枝は下顎体下線と下顎枝後綫の交わる角を指す境界部分およびその輪郭の角度を示すため、両者は別個に測定しなければならない。下顎枝角は成長期の全期間を通じて 5°〜12°減少し、加齢により 4°増加した。下顎枝角はゴニオ束および前ゴニオ束の 2 つの角度で表し、両者は成長期の前半で 6°減少した。その後、前者は加齢で 1°増加し、後者は成長期の後半はもちろん加齢においても有意な増減は認められなかった。すなわち、下顎枝の輪郭をつくる下顎枝下線と下顎体下線は、永久歯の萌出や喪失による咀嚼筋の機能変化に密接しながら異なった変化を示していた。
Introduction

Many reports have been published with regards to changes in the angle of the ramus of the mandible (the condylar angle) and the angle of the mandible in the course of growth from infancy to adulthood. Tsusaki (1962), Makita (1971), Nakaya (1971), Goss (1973), Feneis (1975) and Kahle et al. (1982) explained that the mandibular angle decreases as teething children grow to adolescence and later reach the prime of life with the permanent dentition replacing primary teeth, and starts to increase when they arrive at senescence and lose their teeth.

On the other hand, Brodie (1940), Iizuka (1966), Kamijo (1966) and Dubrul (1980) emphasized that an angle in the geometric sense of the mandibular angle changes but the contour of the mandibular angle does not change with growth and aging, resting on the results of analyses of X-ray cephalographs and serial radiographs. Sakurada et al. (1986) reported that no changes in the condylar angle occur with growth and aging. Kikuchi (1975) and Kubota and Muramatsu (1989) have come up with the results that the condylar angle tends to become obtuse with age but that there were differences in the degree of changes between men and women. Kikkawa (1984) maintained that the protrusion of the mandibular angle is more distinguishable in men than in women. Watanabe (1981) described that morphological changes are evident and the degree of the mandibular angle becomes notably larger in people of advanced age with edentulous jaws than those the dentulous jaws. More recently, Morita et al. (1992) reported their findings that the toothless persons have a larger degree of the condylar angle than the persons with 14 or more teeth, and that salient morphological changes have been taken place in the area adjacent to the mandibular angle.

Generally, the terms angle of the ramus of the mandible and angle of the mandible have been used without being defined precisely. The former is almost always used with reference to the angle formed by the body of the mandible and the ramus. The latter is used sometimes to mean the degree of the angle and sometimes to denote a certain region of the mandible, or at other times, both. The situation is such that the distinction between both terms has remained confused (Fig. 1). Dubrul tried to eliminate this confusion by giving the terms with clear definitions. He first placed a mandible on a table to which a hinged leaf is fastened and gave the term “the condylar angle” (an anthropologic angle) to the inclination of the molar leaf to the table in a position where the leaf touches the posterior border of the mandibular ramus at two points, one near the condyle and the other near the mandibular angle. Meanwhile, the contour of an angu-
lar region existing on the boundary between the inferior border of the body of the mandible and the posterior border of the mandibular ramus was named "the gonial angle". However, he has not made a reference to the range of the gonial angle.

In a previous study, the authors (1992) defined the scope of the mandibular angle. On this premise, an examination was made on the shape and symmetry of the posterior and inferior borders of the mandibular angle. As a result, it was recognized that various changes in from occur with the transition of the stages from the completion of the primary dentition to the loss of teeth through the eruption of permanent teeth.

In the present study, drawing a clear distinction between the condylar angle and the mandibular angle, we made detailed examinations of the changes of both angles during growth as well as aging.

**Materials and Methods**

The materials are the same as those used in a previous report by the authors (1992) (Table 1). A total of 278 pieces of the right and left sides from 140 dried mandibles of Asian Indians, their sex unknown, were employed (2 pieces were excluded because both had the broken ramus). The mandibles were classified into four groups in accordance with Hellman's classification of developmental stages -- the completion of deciduous dentition (IIA), the completion of second molar eruption (IVA), third molar eruption to its completion (IVC·VA) and edentulous (VIIEJ) stages. The materials we used in stage VIIEJ include two mandibles, each with only one tooth left.

The method is exactly the same as the previously employed standard photography. Figure 2 illustrates the region of the mandibular angle and the measuring points. On the life-size photographs of the lateral aspect of the mandibles, the straight line M tangent to the inferior border of the body of the mandible and the straight line P touching the curve of the posterior border of the ramus were drawn, and the point where the two lines intersect was given as G. A point which line P touches the mandibular angle was given as Gp. Then, line H which passes through the posterior border of the articular process and which is perpendicular to line M was drawn, and the point where a horizontal dash line starting at 1/8 of the length of line H on the inferior side of the mandible meets the posterior border of the ramus was given as Ga. An antegonion where the highest point of the concavity of the lower border of the ramus joins the body of the mandible was given as Gm. A straight line was drawn to connect Ga with point Gm (antegonion), and the point where the perpendicular line extending from the midpoint of line Gm-Ga reaches the posterior border of the angle of the mandible was given as Gb. The point were a horizontal dashed line beginning at 1/4 of

**Table 1** Distribution of the mandibular specimens in accordance with Hellman's classification of developmental stages.

<table>
<thead>
<tr>
<th>Group</th>
<th>Mandibles</th>
<th>Right and left sides</th>
</tr>
</thead>
<tbody>
<tr>
<td>II A</td>
<td>61</td>
<td>121</td>
</tr>
<tr>
<td>IVA</td>
<td>19</td>
<td>38</td>
</tr>
<tr>
<td>IVC·VA</td>
<td>27</td>
<td>54</td>
</tr>
<tr>
<td>VIIEJ</td>
<td>33</td>
<td>65</td>
</tr>
<tr>
<td>total number</td>
<td>140</td>
<td>278</td>
</tr>
</tbody>
</table>
Table 2  Means, standard deviations and coefficients of variation of the condylar angle, and $t$ tests for variables between groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>MN</th>
<th>S.D.</th>
<th>C.V.</th>
<th>Max.</th>
<th>Min.</th>
<th>Range</th>
<th>difference between the stages</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>132</td>
<td>5.0</td>
<td>3.8</td>
<td>143</td>
<td>118</td>
<td>25</td>
<td>-5</td>
<td>**</td>
</tr>
<tr>
<td>IVA</td>
<td>127</td>
<td>6.6</td>
<td>5.2</td>
<td>142</td>
<td>115</td>
<td>26</td>
<td>-7</td>
<td>**</td>
</tr>
<tr>
<td>IVC + VA</td>
<td>120</td>
<td>6.5</td>
<td>5.4</td>
<td>135</td>
<td>110</td>
<td>25</td>
<td>6</td>
<td>**</td>
</tr>
<tr>
<td>VIIIEJ</td>
<td>126</td>
<td>6.8</td>
<td>5.4</td>
<td>138</td>
<td>106</td>
<td>31</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** *p<0.01

Table 3  Means, standard deviations and coefficients of variation of the gonial angle, and $t$ tests for variables between groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>MN</th>
<th>S.D.</th>
<th>C.V.</th>
<th>Max.</th>
<th>Min.</th>
<th>Range</th>
<th>difference between the stages</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>161</td>
<td>8.1</td>
<td>5.0</td>
<td>180</td>
<td>123</td>
<td>56</td>
<td>-6</td>
<td>**</td>
</tr>
<tr>
<td>IVA</td>
<td>155</td>
<td>6.2</td>
<td>4.0</td>
<td>167</td>
<td>141</td>
<td>25</td>
<td>-3</td>
<td>N.S.</td>
</tr>
<tr>
<td>IVC + VA</td>
<td>152</td>
<td>8.9</td>
<td>5.8</td>
<td>172</td>
<td>136</td>
<td>36</td>
<td>4</td>
<td>**</td>
</tr>
<tr>
<td>VIIIEJ</td>
<td>156</td>
<td>6.8</td>
<td>4.3</td>
<td>171</td>
<td>137</td>
<td>33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.S. : no significance, ** *p<0.01

Table 4  Means, standard deviations and coefficients of variation of the antegonial angle, and $t$ tests for variables between groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>MN</th>
<th>S.D.</th>
<th>C.V.</th>
<th>Max.</th>
<th>Min.</th>
<th>Range</th>
<th>difference between the stages</th>
<th>t-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>10</td>
<td>5.3</td>
<td>56.0</td>
<td>23</td>
<td>0</td>
<td>23</td>
<td>-6</td>
<td>**</td>
</tr>
<tr>
<td>IVA</td>
<td>4</td>
<td>5.2</td>
<td>137.4</td>
<td>17</td>
<td>0</td>
<td>17</td>
<td>2</td>
<td>N.S.</td>
</tr>
<tr>
<td>IVC + VA</td>
<td>6</td>
<td>6.0</td>
<td>91.0</td>
<td>16</td>
<td>0</td>
<td>16</td>
<td>-1</td>
<td>N.S.</td>
</tr>
<tr>
<td>VIIIEJ</td>
<td>5</td>
<td>6.0</td>
<td>109.1</td>
<td>22</td>
<td>0</td>
<td>22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.S. : no significance, ** *p<0.01

the inferior side of the length of line H comes into touch with the tangent line P to the posterior border of the ramus was given as Gy. The straight line distance from G to Gy was sought anteriorly on line M and was given as Gx. A point where a perpendicular line to Gx on line M meets the inferior border of the body of the mandible was given as Gx'. The two points Gx' and Gm were connected with a straight line.

The condylar angle and the mandibular angle were measured on the digitizer by the 4-point angular calculation method. The means values, standard deviations and coefficients of variation of the condylar angle, gonial angle and antegonial angle were summarized for the purpose of statistical analysis. Significant differences in the mean values between Hellman's developmental stages were assessed by the Student's $t$-test and the Welch $t$-test.

Results

The mean values, standard deviations, and coefficients of variation on the degree of angle of the condylar angle, gonial angle and antegonial angle are shown in Tables 2, 3 and 4.
The method of measurement of the condylar angle is shown in Figure 3 (a). For measuring the condylar angle, the angle formed between the inferior border of the body of the mandible (line M) and the posterior border of the ramus (line P) was used. Changes in the degree of the condylar angle are shown in Table 2. The condylar angle in stage IIA was 132±5 degrees, which significantly (p<0.01) decreased by 5 degrees to 127±6 in stage IVA. The value further dropped significantly by 7 degrees (p<0.01) to 120±6 in the stage of IVC•VA. In stage VIIEJ, however, it showed a significant (p<0.01) increase of 6 degrees from IVC•VA and reached 126±6. The angular range was from 25 to 31 degrees and the coefficients of variation was worked out to be 3.8% to 5.4%. The condylar angle tended to gradually decline throughout the period of growth of the mandible from stage IIA to stage IVC•VA, and turned upward with aging from stage IVC•VA to stage VIIEJ.

The method of measurement of the gonial angle is shown in Figure 3 (b). To obtain the degree of the gonial angle, the angle formed by the three points - Ga and Gb in the posterior border of the mandibular angle and Gm observed in the lowest border of the mandibular angle (≤Ga•Gb•Gm) - was taken. Changes in the degree of angle of the gonial angle are shown in Table 3.

The gonial angle in stage IIA was 161±8. In stage IVA, the value dropped significantly (p<0.01) by 6 degrees to 155±6. The value continued to decrease to 152±8 in stage IVC•VA. But the decrease of 3 degrees from stage IVA is not significant. The decreasing trend turned upward in stage VIIEJ to 156±6, a significant (p<0.01) rise of 4 degrees from stage IVC•VA. The angular range was from 25 to 56 degrees, exceeding the range of the condylar angles. The coefficients of variation came up to 4.0~5.8%, approximating to that of the condylar angle. The degree of the gonial angle decreased during the growth period from stage IIA to stage IVC•VA, and increased from stage IVC•VA to stage VIIEJ due to aging. Such variations in the gonial angle were almost parallel with those in the condylar angle.

The method of measuring the antegonial angle is shown in Figure 3 (c). The inferior border of the body of the mandible was not necessarily flat and varied in shape depending upon the development of the antegonial notch. In the present study, the measurement of the antegonial angle was taken at ≤Gx'•Gm•Gx, formed by Gx' and Gm on the inferior border of the mandibular angle and Gx on line M.

Table 4 shows the angular changes of the antegonial angle. The antegonial angle measured 10±5 in stage IIA of the mandibles and 4±5 in stage IVA, showing a significant (p<0.01) decrease of 6 degrees. The angle increased by 2 degrees to 6±6 in stage IVC•VA, however, there is no significant difference. An antegonial angle in stage IVC•VA came to decrease again by an insignificant 1 degree to 5±6 in stage VIIEJ. The angular range of 16 to 23 was smaller than to the range of the condylar angle. The coefficients of variation varied as wide as 56.0~137.4%. The degree of the antegonial angle decreased only from stage IIA to stage IVA which correspond to the first half of the period of growth. The angle during the latter half of the period of growth, from stage IVA to stage IVC•VA and further stages from IVC•VA to VIIEJ, there were no salient angular changes due to
Fig. 4 Changes in the condylar angle with growth and aging.

Discussion

The degree of the mandibular angle, if measured by a mandibulometer\(^9\) as described in a Martin-Saller textbook or a stativgoniometer\(^9\) in Suzuki's "Anthropometry", can be expressed in an angle formed by two straight lines, despite the fact that the posterior border of the mandibular ramus and the inferior border of the body of the mandible are irregularly curved. The shortcomings of this method are that the measurements are affected considerably by the growth of the condylar cartilage and the morphological changes in the posterior border of the articular condyle due to the loss of premolars and molars and disorder of the masticatory function. Furthermore, the shape of the posterior border of the mandibular angle is rounded and the depression of the antegonial notch in the inferior border of the mandible is neglected. It cannot be said that the results obtained by the conventional report fully reflect the appropriate shape of the mandibular angle.

To overcome the above-mentioned shortcomings, the present authors\(^7\) limited the range of the mandibular angle to the area Gy-G in 1/4 of the height of the ramus and the area Gx-G on line M tangent to the inferior border of the body of the mandible. We stud-
to the development of the mandible and the stress of
the muscles of the mastication attached to it with
growth of physique\textsuperscript{21,22}, which results in the decrease
in the condylar angle\textsuperscript{23-26}).

Likewise, the changes in the growth period of the
gonial angle become smaller (Fig. 5). The angle
shown in stage IIA was 161 degrees, and in stage IVA
it decreased significantly by 6 degrees. Then, angular
changes were not significantly observed in stage
IVC-IVA. This suggests that before the eruption of
the second molar is complete, the posterior border of
the mandibular angle, which undergoes a mor-
phological change to adapt to the development of the
muscles of mastication and their muscular function, is
not subject to the myofunctional strength with the
eruption of wisdom teeth. After stage IVC-VA,
however, the condylar angle expanded by 6 degrees
and the gonial angle increased by 4 degrees, with loss
of all teeth (Fig. 5). This can be attributed to the
hypofunction of the muscles of mastication due to the
loss of the vertical dimension, which results in the
decrease in myodynamics and a change in the shape of
the area to which the muscles are attached. The
angular changes in the gonial angle from Ga to Gm
could be observed clearly even if measurements are
taken without regard to the effects of the loss of teeth
on the posterior border of the condyle.

The changes in the angle between the inferior bor-
der of the mandibular angle and the horizontal plane
are shown in Figure 6. The angle taken in stage IIA
was 10 degrees, which dropped to 6 degrees in stage
IVA but remained almost the same in stage IVC-VA.
It suggested that the drift\textsuperscript{27} of the location to a
posterosuperior region near the mandibular angle and
the remodeling of bone in the antegonial notch scarce-
ly occurred due to the eruption of wisdom teeth. Even
after all the teeth are lost, our study showed that the
anterognathic notch, once formed, does not change
notably. The Gx'-Gm in the inferior border of the
mandibular angle rarely came into contact with the
horizontal plane in either stage. It separated from the
plane almost all of the mandibles used in our study.
This observation differs from that of Watanabe\textsuperscript{15}
who asserted that an area adjacent to the mandibular
angle was absorbed with aging and was straight in
edentulous jaws, but agrees with Ichijyo's
observation\textsuperscript{28} that there was a shallow depression.
The bone remodeling in the antegonial notch observed
posterior to the inferior border of the body of the
mandible was remarkable only during the first half of
the growth period.

From all the results mentioned above, it can be said
that the condylar angle changes notably with the
replacement of teeth, the eruption of additional teeth
and complete loss of teeth. It was also suggested that
morphological changes in the lower and posterior
border of the ramus and the backward and inferior border of the body of the mandible contouring the mandibular angle occur differently but are closely related with the changes in the function of the muscles of mastication due to the eruption as well as the loss of permanent teeth.

Acknowledgments

We wish to thank our research associate Miss Keiko Ohmura, for her kind assistance in carrying out the present study.

References

24) Masuda, T.: Kagakukotsu no kouzo narabini

