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THE SAGITTAL GROWTH OF THE LOWER FACE DURING FOETAL LIFE

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The mandibular line (ML) seems to show stability with both the anterior cranial base (NSL) and with the Nasal Line (NL) during foetal life. The jaw angle, gn—go—co also shows angular stability during the same period. These findings suggest that the lower jaw follows the angular changes found in the cranial base, nasal septum and the upper jaw, the primary factor being possibly the cranial base. There is a reduction in the prognathic development of the lower jaw in the period investigated. Increased lower face prognathism seems to be associated with an anterior rotation of the lower jaw. Lower anterior facial height increases more than upper anterior facial height whereas horizontal growth of the lower face shows less increase than the anterior cranial base, nasal septum and upper jaw. Increased lower face height is followed by a long lower jaw, a large jaw angle and an increased distance between the condyle and NSL. Increase in the sm-NSP distance seems to be associated with a relative anterior position of the condyle, increased length of the mandibular body and increased height of the mandibular ramus.

The lower face is defined as the anatomical area lying between the Nasal Line (NL) and the Mandibular Line (ML). The lower face contains the oral cavity.

Levihn (1961) found a small but gradual increase in the sm—n—s angle, i.e. in the prognathic development of the lower jaw, between 12 and 40 weeks intrauterine life and nearly a doubling of the ss—n—sm angle (from 8.0 to 15.5°) in the same period.

Brodie (1953) in postnatal material found that the mandibular border showed no appreciable angular changes to the cranial base during growth. In those cases where he found angular changes there was a tendency for the mandibular border to become more parallel with the anterior cranial base.

The present investigation is a metric anthropological and roentgen-anatomical study of the lower facial skeleton in its sagittal growth process.

Cephalometric landmarks, angles and reference lines have been used. This has been made possible by the dissection technique used and by the application of contrast medium for the roentgenographic technique.

MATERIAL AND METHODS

The present study relates to 159 human foetuses, 87 from the Institute of Anatomy, University of Bergen (Bergen material) and 72 from the Anatomy Department, Queens University of Belfast, Northern Ireland (Belfast material). Chronologically the foetal materials correspond to approximate foetal ages of 10 to 33 weeks.

The material and methods have been previously described in detail (*Kvinnsland, 1971*).

RESULTS

Developmental changes

All variables have been correlated to the Occipito Frontal diameter (HL) and expressed in terms of the correlation index (r_m). For all measurements a polynomic regression equation has been used varying from 1st to 4th degree depending on which value of r_m gives the best possible description of association between the variables in cases where this is an improvement on a linear regression equation. The regression equation used is stated for each individual variable in the scatter diagram, as is the correlation index (r_m). A correlation index value (r_m) of 0.50 has been selected as the lowest value to express a significant association. Where $r_m \geq 0.50$ a regression line has been drawn in the scatter diagram. The abscissa always denotes the Occipito Frontal diameter (HL).

For reference points, reference lines, angles and linear measurements used in the investigation, the reader is referred to Fig. 1.

Angular measurements

Mandibular Line — Nasal Line (ML—NL) (40) (Fig. 2). The mandibular plane angle expressing the relationship between the anterior and posterior height of the lower face. This angle shows great individual variation but no general tendency to change with the various stages of development. This angle has been measured in the Bergen material only.

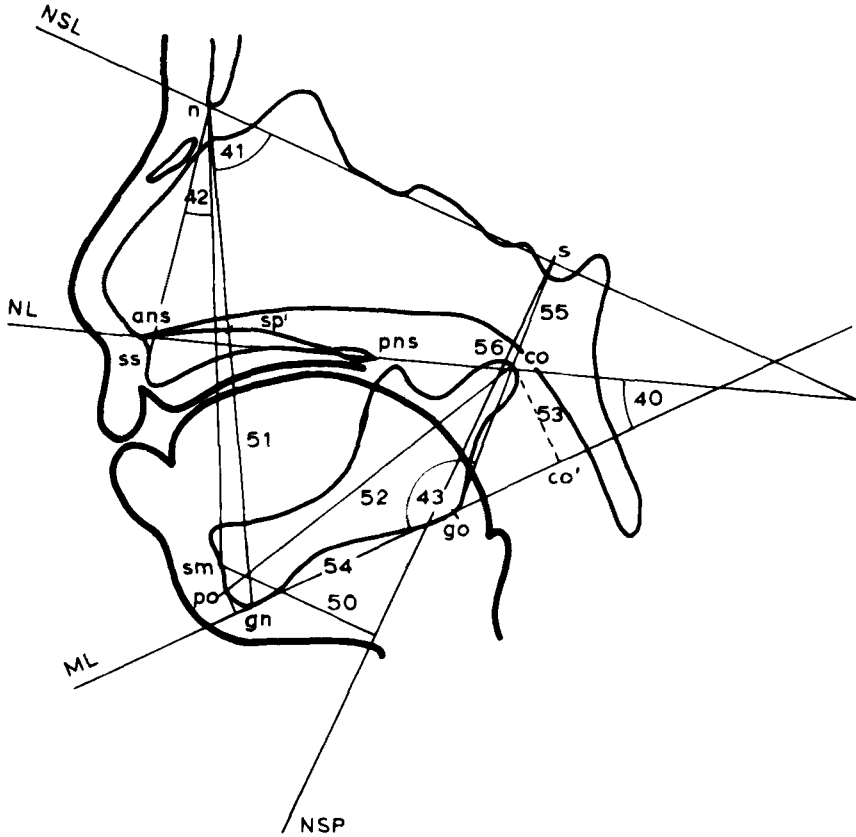


Fig. 1. Reference points, reference lines, angular and linear measurements.

n — nasion: point of intersection of the most caudal point on the frontal bone and the mid-sagittal plane (M.S.P.). s — Sella: the center of the sella turcica in the M.S.P. ans — anterior nasal spine. pns — posterior nasal spine. ss — subspinale: point in the M.S.P. where the anteroinferior contour of the anterior nasal spine merges with the maxillary alveolar process. sp' — point of intersection between the Nasal Line (NL) and a line between n and gn in the M.S.P. sm — supramentale: point in the M.S.P. where the antero-superior contour of the mandibular symphysis merges with the mandibular alveolar process. po — pogonion: the most anterior point on the mandibular symphysis in the M.S.P. gn — gnathion: The lowest point on the mandibular symphysis in the M.S.P. go — gonion: The point on the contour of the mandibular angle decided by halving the tangent angle. co — condylon: the most cranial point on the convex surface of the mandibular condyle. co' — condylon': the projection of co on ML. NSL — Nasion Sella Line: a line through n and s. NL — Nasal Line: a line through ans and pns. ML — Mandibular Line: a line through gn and go. NSP — Nasion Sella Perpendicular: a line through Sella (s) perpendicular on NSL. ML — NL (40): The mandibular plane angle expressing the relationship between the anterior and posterior height of the lower face. sm — n — s (41): The facial angle expressing the relationship between the mandibular apical base and NSL, commonly used to express the prognathic development of the lower jaw. ss — n — sm (42): The angle expressing the horizontal relationship between the maxillary and mandibular apical bases. gn — go — co (43): The jaw angle. sm — NSP (50): The antero-posterior relationship of the most anterior part of the mandibular apical base to Sella. sp' — gn (51): The anterior height of the lower face measured along the n — gn line. po — co (52): the measurement for the mandibular apical base. co — co' (53): the vertical height of the ramus. po — go (54): the horizontal length of the body of the mandible. co — NSL (55): The vertical distance between the superior aspect of the mandibular condyle and the NSL. co — NSP (56): the horizontal distance between co and s.

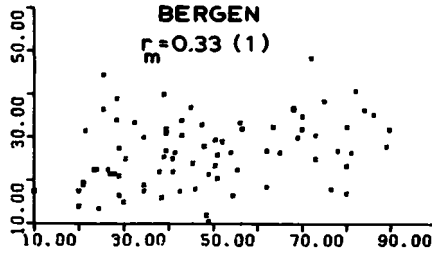


Fig. 2. The relationship between the angle III — NI, and HI.

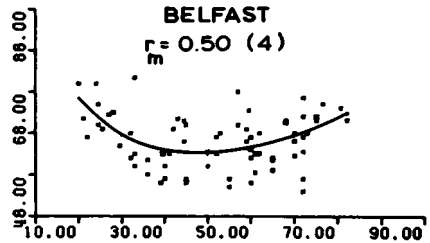
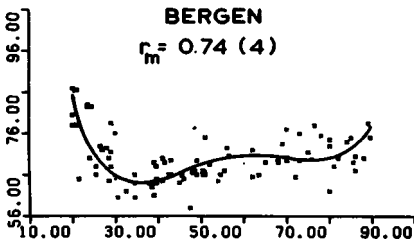


Fig. 3. Developmental changes in the angle sm — n — s.

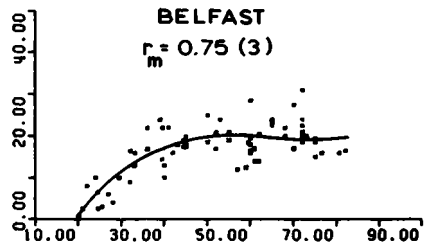
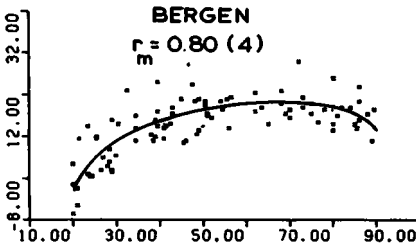


Fig. 4. Developmental changes in the angle ss — n — --- sm.

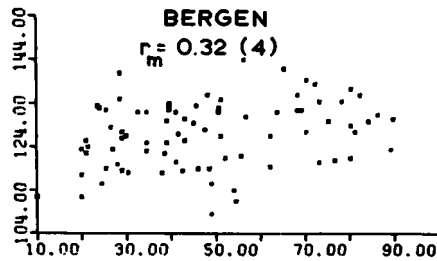


Fig. 5. The relationship between the angle gn — go — co and III.

Supramentale — Nasion — Sella (sm—n—s) (41) (Fig. 3). The facial angle expressing the relationship between the mandibular apical base and Nasion Sella Line (NSL), commonly used to express the prognathic relationship of the lower jaw. In the Bergen material the angle shows an initial reduction from 85.1° at 20.0 mm HL to 64.3° at 34.0 mm HL, thereafter a gradual increase, 68.8° at 55.5 mm HL, 69.7° at 70.0 mm HL and 77.1° at 89.5 mm HL. In the Belfast material the general tendency is nearly the same, 76.0° at 20.0 mm HL, 62.9° at 50.0 mm HL and 72.8° at 82.0 mm HL.

Subspinale — Nasion — Supramentale (ss—n—sm) (42) (Fig. 4). The difference between angle ss—n—s and sm—n—s, expressing the horizontal relationship between the maxillary and mandibular apical bases. In the Bergen material the angle shows a rapid increase in the early period from 0.8° at 20.0 mm HL to 17.0° at 50.0 mm HL, a more gradual increase in the middle period, 20.3° at 75.0 mm HL and an actual decrease towards the end, 14.8° at 89.5 mm HL. In the Belfast material there is an increase in the early period from 1.4° at 20.0 mm HL to 19.1° at 50.0 mm HL followed by relative stability of the angle, 19.3° at 70.0 mm HL and 19.3° at 82.0 mm HL.

Gnathion — Gonion — Condylon (gn—go—co) (43) (Fig. 5). The jaw angle. This angle shows great individual variation but no tendency to change during the foetal period under investigation. This angle has been measured in the Bergen material only.

Linear measurements

Supramentale — Nasion Sella Perpendicular (sm—NSP) (50) (Fig. 6). The antero-posterior relationship of the most anterior part of the mandibular apical base to Sella. This measurement increases from 5.4 mm (Bergen material) and 6.0 mm (Belfast material) at 20.0 mm HL to 19.1 mm at 89.5 mm HL (Bergen material) and 19.9 mm at 82.0 mm HL (Belfast material).

Nasal Line — Gnathion (sp'—gn) (51) (Fig. 7). The anterior height of the lower face increased from 4.0 mm (Bergen material) and 4.3 mm (Belfast material) at 20.0 mm HL to 21.3 mm at 89.5 mm HL (Bergen material) and 18.5 mm at 82.0 mm HL (Belfast material).

The following measurements were measured on the Bergen material only.

Pogonion — Condylon (po—co) (52) (Fig. 8). The measurement for the mandibular apical base. The distance increased from 8.3 mm at 20.0 mm HL to 30.1 mm at 89.5 mm HL.

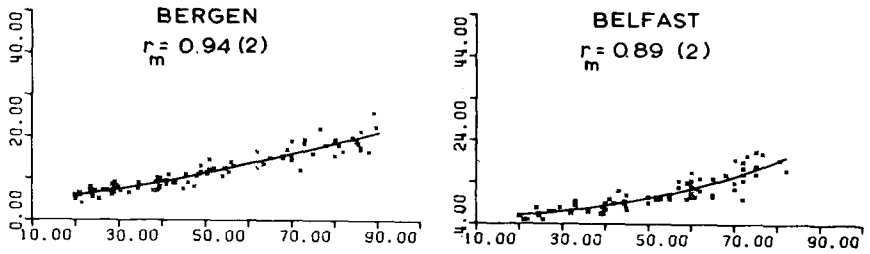


Fig. 6. Linear increase in the sm -- NSP distance.

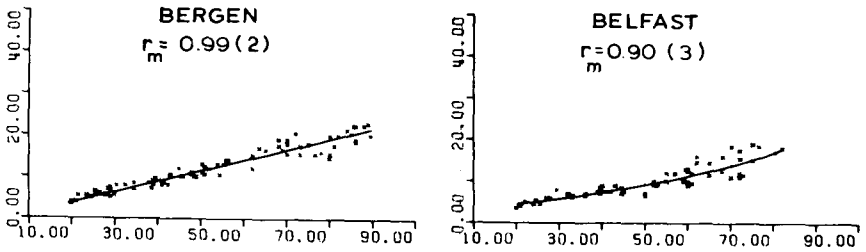


Fig. 7. Linear increase in the sp' -- gn height.

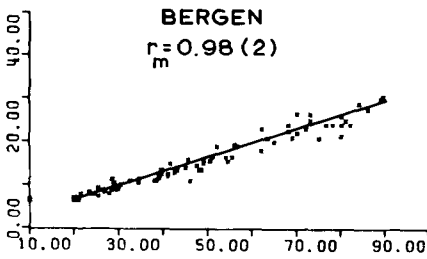


Fig. 8. Linear increase in the po -- co length.

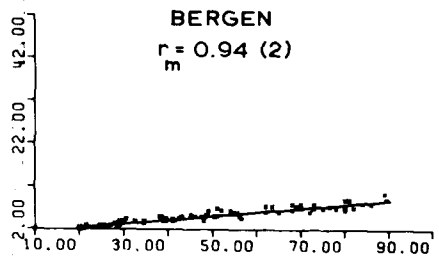


Fig. 9. Linear increase in the co -- co' distance.

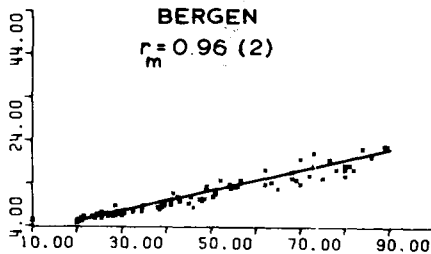


Fig. 10. Linear increase in the po -- go length.

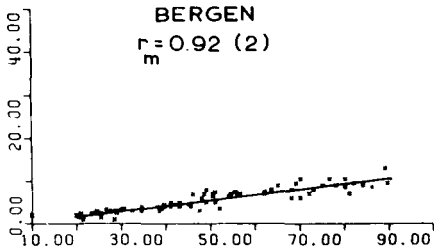


Fig. 11. Linear increase in the co — NSL distance.

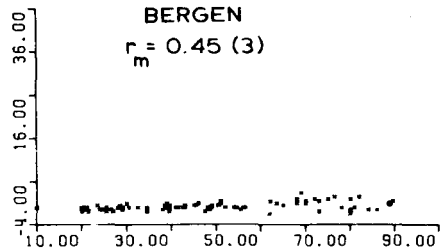


Fig. 12. Linear increase in the co — NSP distance.

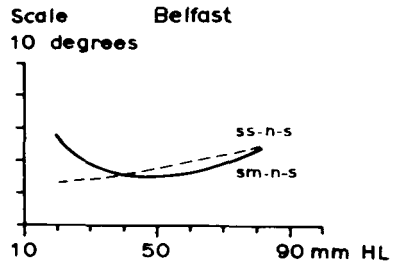
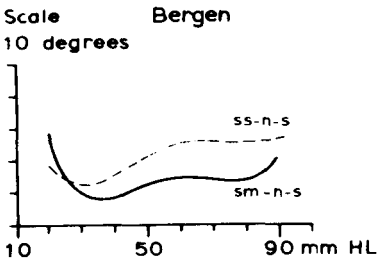


Fig. 13. Curves comparing the developmental changes taking place in maxillary and mandibular prognathism (ss — n — s and sm — n — s).

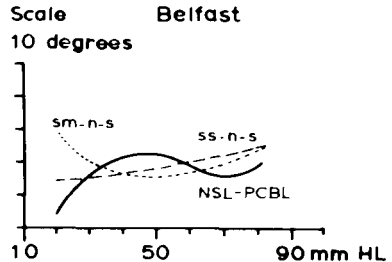
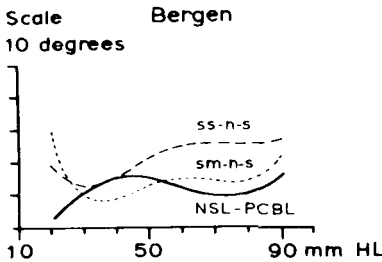


Fig. 14. Curves comparing the angular changes that take place in ss — n — s and sm — n — s, and how these changes are related to angular changes in the cranial base.

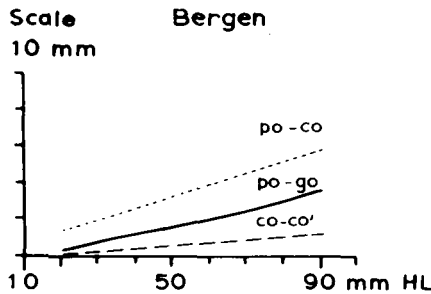


Fig. 15. Curves comparing the amount of growth of the mandibular apical base (po — co) the horizontal length of the body of the mandible (po — go) and the vertical height of the ramus (co — co').

The vertical mandibular base (co-co') (53) (Fig. 9). The vertical height of the ramus increased from 2.3 mm at 20.0 mm HL to 8.6 mm at 89.5 mm HL.

Pogonion — Gonion (po-go) (54) (Fig. 10). The horizontal length of the body of the mandible shows an increase from 5.4 mm at 20.0 mm HL to 21.7 mm at 89.5 mm HL.

Condylon — Nasion Sella Line (co-NSL) (55) (Fig. 11). The vertical distance between the superior aspect of the mandibular condyle and the NSL. This measurement increased from 1.5 mm at 20.0 mm HL to 10.2 mm at 89.5 mm HL.

Condylon — Nasion Sella Perpendicular (co-NSP) (56) (Fig. 12). The horizontal distance between co and s. Although there is a slight tendency for the condyle to come forward in relationship to s in the period investigated, from -0.3 mm at 20.0 mm HL. (posterior to s) to 1.1 mm at 89.5 mm HL (anterior to s) the correlation index (rm) is low, 0.45.

Correlations

The correlation coefficient (r) has been used to express the relationship between the examined pairs of variables, see Tables I and II.

Table I.
Correlations between the variables in the lower face

	Group	n	sp'-gn	n	sm-n-s	n	gn-go-co	n	po-co	n	po-co'	n	co-co'	n	po-go	n	co-NSP	
sm-NSP	Bergen	87	0.88						80	0.95	80	0.95			80	0.95	80	0.44
	Belfast	72	0.88															
ss-n-sm	Bergen			87	-0.54													
	Belfast			72	-0.47													
ML-NL	Bergen	80	0.49	80	-0.30	80	0.60											
gn-go-co	Bergen	80	0.36															
po-co	Bergen	80	0.46									80	0.91	80	0.98			
po-go	Bergen	80	0.92							80	0.89							
co-NSL	Bergen	80	0.90															

Table II.
Correlations between the variables in the total face, and between the variables in the total face and cranial base, upper face and lower face.

	Group	n	acbp-pr-s	n	n-s	n	n-sp	n	ss-pns	n	sp'-gn	n	ss-n-sm	n	ML-NSL
ACBL-PCBL	Bergen													80	0.30
NSL-PCBL	Bergen													80	0.37
n-sp'	Bergen													80	0.33
n-gn	Bergen Belfast	87 72	0.77 0.69	87 72	0.98 0.94	87 72	0.98 0.97	87 72	0.97 0.96	87 72	0.99 0.99	87 72	0.65 0.47	80	0.39
sp'-gn	Bergen													80	0.42
sm-n-s	Bergen													80	-0.57
ss-n-sm	Bergen													80	0.54
ML-NL	Bergen				0.31									80	0.91

DISCUSSION

In this study four angular and seven linear measurements have been used to examine differential direction of growth of the lower face. In the present study ML—NL, ML—NSL and gn—go—co have been measured in the Bergen material only. The mandibular line (ML) to the Nasal Line (NL) i.e. the angle expressing the relationship between the anterior and posterior height of the lower face, seemed to show stability during the foetal period, the same was found in the angle ML—NSL. The angle gnathion—gonion—condylon (gn—go—co), the jaw angle, also showed stability in the same period. These findings seem to agree with *Brodie* (1941, 1953) who found a remarkable stability and parallelism of growth between the cranial plane, maxillary plane and mandibular plane in the early postnatal period.

The present findings seem to suggest that the lower jaw follows the angular changes found between the anterior cranial base, nasal septum (SL) and palatal plane (NL) in relationship to the posterior cranial base, the primary factor being, possibly the angular changes of the cranial base. This would then account for the parallelism found between these four planes (NSL, SL, NL and ML) at least when comparing the earliest and latest foetal stages. The angle sm—n—s expressing the prognathic relationship of the mandible to NSL, showed an initial rapid reduction followed by a gradual increase. The net result is a reduction in the sm—n—s angle of 8.0° and 3.2° (Bergen and Belfast materials) in the periods investigated (Figs. 13 and 14).

The correlation analysis of the lower face shows a negative correlation between $sm-n-s$ and $ML-NSL$ (Table II), and between $sm-n-s$ and $ML-NL$ in the Bergen material, and negative correlation between $sm-n-s$ and $ss-n-sm$ in both materials (Table I). This suggests that the increased prognathic relationship of the lower jaw is associated with small $ML-NSL$ and $ML-NL$ angles, whereas there seems to be no correlation in the present material between the length factor of the mandible, $po-co$ and $po-go$, and the prognathic development of the lower jaw ($sm-n-s$). The correlation analysis further shows that a large jaw angle, $gn-go-co$ is followed by a large $ML-NL$ angle (Table I).

Ford (1955) found that growth of the lower jaw lags behind that of the upper between 12 and 20 weeks intrauterine life, while *Birch* (1968) found that the state of mandibular retrognathism is a common and fairly constant feature between 10 and 27 weeks of foetal life.

Levihn (1961) found the lower anterior facial height to increase from 53.0 to 57.3 per cent of total anterior facial height between 12 and 40 weeks, he further found the distances $ans-pns$ (the length of the nasal flow) and $gn-go$ (the approximate length of the body of the mandible) to increase with an equal amount between 12 and 40 weeks.

In the present study $sm-NSP$ increased by 13.7 mm and 13.9 mm in the Bergen and Belfast materials respectively in the period under investigation. The distance $po-co$, the measurement for the mandibular apical base, $po-co'$, the horizontal mandibular base, and $po-go$ the horizontal length of the body of the mandible, all showed a substantial increase in the foetal period, whereas $co-co'$, the vertical height of the ramus exhibited a smaller increase in the same period (Fig. 15).

The correlation analysis seems to show that increased lower face height, $sp'-gn$ is followed by a large lower jaw ($po-go$ and $po-co$) a large jaw angle ($gn-go-co$) and a relative large vertical distance between co and NSL (Table I).

Furthermore there seems to be association between the relative antero-posterior position of the condyle and the distance $sm-NSP$ as there is positive correlation between $co-NSP$ and $sm-NSP$. There is, furthermore, positive correlation between $po-go$ and $sm-NSP$, between $po-co$ and $po-go$, between $po-co'$ and $po-go$ and between $sm-NSP$ and $po-co$ (Table I) which tends to show that the antero-posterior position of supramentale (sm) in relation to Sella (s) is associated with the total length of the mandibular base, the length of the mandibular body as well as the height of the ramus.

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