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Morphology of the mandibular canal and the angulation between the mandibular and mental canals in dry skulls

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SUMMARY The aim of this study was to analyse the correlation between external and internal mandibular morphology in adult or adolescent normal anthropological mandibles. Lateral radiographs of 31 symmetrical mandibles were analysed. The external morphology was defined by the gonial and β-angles. In order to analyse internal morphology, a metallic pin was placed in the mental canal on the left side before radiography. The angle between the mental and the mandibular canals was termed the 'mental angle' and that expressing the curvature of the mandibular canal, the 'mandibular angle'. Spearman correlation analysis was used to investigate the relationships between the angles.

Internal morphology: a statistically significant correlation was found between the mental and mandibular angles (correlation coefficient: –0.60, $P = 0.0004$). When the mental angle was narrow, the mandibular angle tended to be wide, while a wide mental angle was interrelated with a narrow mandibular angle. External morphology: a statistically significant correlation was found between the mandibular and gonial angles (correlation coefficient: 0.57, $P = 0.0009$). A weaker correlation was also found between the mandibular and β-angles.

The findings show that the internal courses of the mandibular and mental canals are interrelated. They also indicated that the course and morphology of the mandibular canal are interrelated with external mandibular morphology.

Introduction

In cephalometric studies with fixed bone markers, Björk (1969) explained the complex rotation processes in normal and abnormal mandibular development and revealed that the mandibular canal is a stable structure during growth. The same bone marker method was also used to demonstrate the growth pattern of the maxillary complex (Björk and Skieller, 1977).

It is known that in pre-natal life, the mandibular canal has a horizontal orientation (Chavez-Lomeli *et al.*, 1996) and that the mental canal has not developed (Kjær, 1989). The mental foramen develops at 9–10 weeks gestational age (Kjær, 1989). The curvature of the mandibular and mental canals will develop during growth and apposition in the late pre- and post-natal periods. As the mandibular canal has a curved course post-natally (Björk, 1969), it is presumed that the mandibular growth pattern is reflected in its curvature.

By superimposing two radiographs taken at different ages and orientating them according to the contour of the mandibular canal, Björk (1969) demonstrated how the growth pattern of the mandible could be determined with a fairly high degree of accuracy. Rotation of the mandibular corpus during growth associated with substantial surface remodelling is well documented (Björk and Skieller, 1983).

Active mandibular growth occurs in the mandibular condyle. The condylar growth pattern is individual and varies in direction and magnitude (Björk, 1969). In vertical condylar growth, the height of the ramus is increased, the mandibular base is curved, and the gonial angle is small. In sagittal condylar growth, the height of the ramus is shorter, the madibular base is less curved, and the gonial angle larger. It is suggested that these different types of external mandibular morphology also reflect different internal morphologies. Of special interest in this context is unilateral condylar hypoplasia because condylar growth in these cases is absent (World Health Organization, 1995). Thus, it would be of interest to study the consequence for the internal mandibular morphology in cases where the healthy condyle grows and the pathological condyle does not.

The aim of the present investigation was to analyse the correlation between the internal morphology, defined by the mandibular and the mental canals, and the external morphology of the mandible.

Materials and methods

From the cranial collection of Professor Arne Björk at the Department of Orthodontics, Copenhagen School of Dentistry, Denmark, all symmetrical mandibles without anomalies, originating from adult or late adolescent individuals were selected for this study, in total 31 mandibles.

Registration of the mental canal

A pin was inserted as a metal marker into the left mental foramen of each mandible (Figure 1). The pin was relatively

Figure 1 Photograph of a normal human adult mandible with a metal pin inserted in the middle of the mental canal (left). Magnification of the mental foramen with the pin (right).

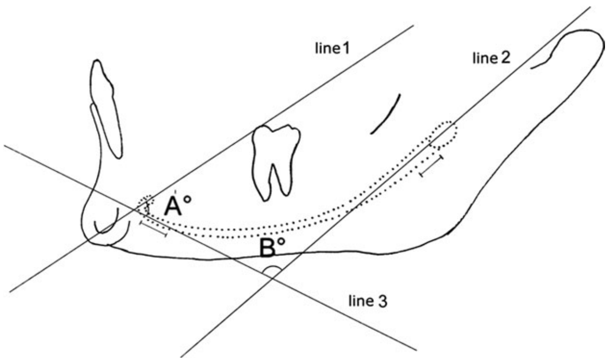

Figure 2 Tracing of a radiograph of a normal human adult anthropological mandible. The dotted lines represent the mental and mandibular foramen and canal. Line 1 represents the direction of the mental canal, line 2 the direction of the mandibular canal close to the mandibular foramen, and line 3 the direction of the mandibular canal closest to the mental canal. A° is the mental angle and B° the mandibular angle.

stable because the point of the pin was locked in the trabecular bone at the end of the mental canal.

Radiography

Lateral radiographs were taken of each mandible with the metal markers inserted in the mental canal. The radiographs were taken at the Department of Radiology, School of Dentistry, Copenhagen, in a Philips/Valmet BR 2002 cephalostat with a film to focus distance of 180 cm. No correction was made for the constant linear enlargement of 5.6 per cent. The radiographic film used was LifeRay XDA Plus UTLG (Ferrania Technologies S.p.A., Cairo Montenotte, Italy). The films were exposed with 50–53 kv and 4–5 mA.

The radiographs were taken with the mandibles placed horizontally on a Plexiglas plate in front of the film. Cephalometric reference points were marked in a first registration directly on the radiograph by one observer (SRP) and controlled by the second observer (IK) and then deleted. After 3 months, this procedure was repeated by SRP. The Bland–Altman method was used in order to quantify the discrepancy between the repeated observations.

Angles expressing external mandibular morphology

Gonial angle: the angle between the mandibular line (ML), a line tangentially to the base of the mandible through the fixed point gnathion (lower point of mental symphysis) and the ramus line, a line tangentially to the posterior border of the mandibular ramus through the fixed point articulare (where the contour of the cranial base and the dorsal contour of the condylar process intersect).

β-angle: the angle between the ML and the line connecting articulare and ML, where the line perpendicular to ML through the fixed point pogonion (most anterior point on the chin) is located.

Cephalometric analysis of internal mandibular morphology

Each radiograph was scanned into a computer and enhanced using Adobe® Photoshop® Elements 2.0 to make the mandibular canal more visible by adjusting size, brightness, and contrast. After adjustment, each copy was printed out with a HP Photosmart 8100 series printer. The bony structures that outline the mandibular foramen and mandibular canal were drawn on these prints with a pencil (Figure 2). A straight line (line 1, Figure 2) was drawn with a ruler on the white marker line from the metallic pin on each print. This line demonstrates the direction of the mental canal on a radiograph. Another line (line 2, Figure 2) was drawn parallel with the first centimetre of the mandibular canal from the mandibular foramen. This illustrates the direction of the mandibular canal closest to the mandibular foramen. Additionally, a third line (line 3, Figure 2) representing the direction of the mandibular canal closest to the mental foramen was drawn.

Table 1 Reliability testing with the Bland–Altman method.

	n	Mean	Standard error	*T* value	Lower	Upper
β-Angle	31	−0.1612903	0.0909540	−1.77	−1.1741	0.8515
Gonial	31	−0.0806452	0.2151478	−0.37	−2.4764	2.3151
Mandibular	31	−3.6129032	1.0198855	−3.54	−14.9699	7.7441
Mental	31	2.7741935	1.0031774	2.77	−8.3967	13.9451

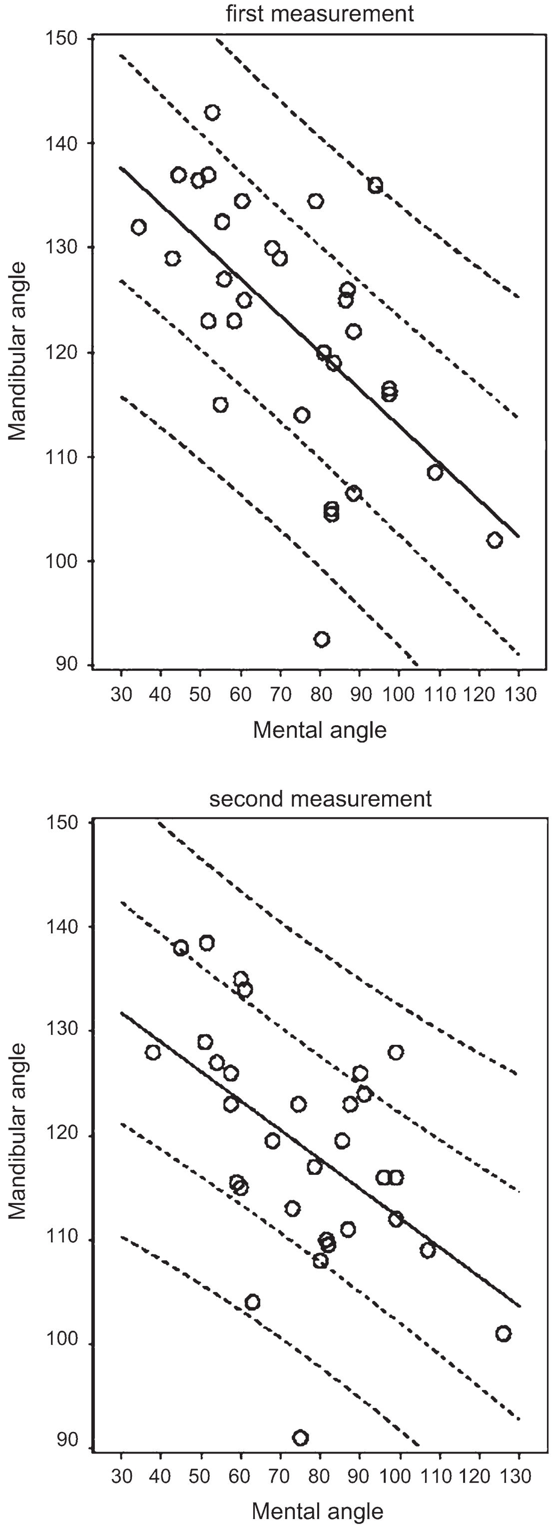

Figure 3 Graphical illustration of the results of inner mandibular morphology evaluated with a Spearman correlation test.

Angles expressing internal morphology

Mental angle: the angle between lines 1 and 3 (Figure 2).

Mandibular angle: the angle between lines 2 and 3 (Figure 2).

External mandibular morphology. The same skeletal landmarks, reference lines, and angles were identified on each mandible.

Internal mandibular morphology. The direction of the mental canal was compared with that of the mandibular canal.

Statistical analysis of interrelationship between angles

In order to avoid an unnecessary assumption of normality, the non-parametric Spearman correlation was used to investigate the relationships between the following angles: the mandibular angle and the mental angle, the mandibular angle and each of the two external mandibular angles, and the mental angle and each of the two external mandibular angles.

Results

Reliability of inner and outer contour measurements

Significant mean differences were found in the inner but not in the outer angles. Line 3 (Figure 2) was the most difficult line to place since the contour of the mandibular canal is not as clear in this region as it is close to the mandibular foramen. This explains the slightly higher discrepancy between the first and second measurements of the mandibular and mental angles (Table 1).

Inner morphology

The correlation between the mental and mandibular angles is illustrated in Figure 3. The correlation coefficient

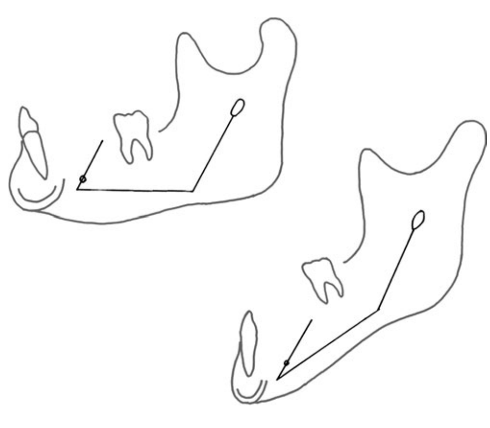

Figure 4 Drawings of two human mandibles illustrating the relationship between the inner mental angle and the inner mandibular angle. If the mental angle is wide, the mandibular angle tends to be narrow. If the mental angle is narrow, the mandibular angle tends to be wide.

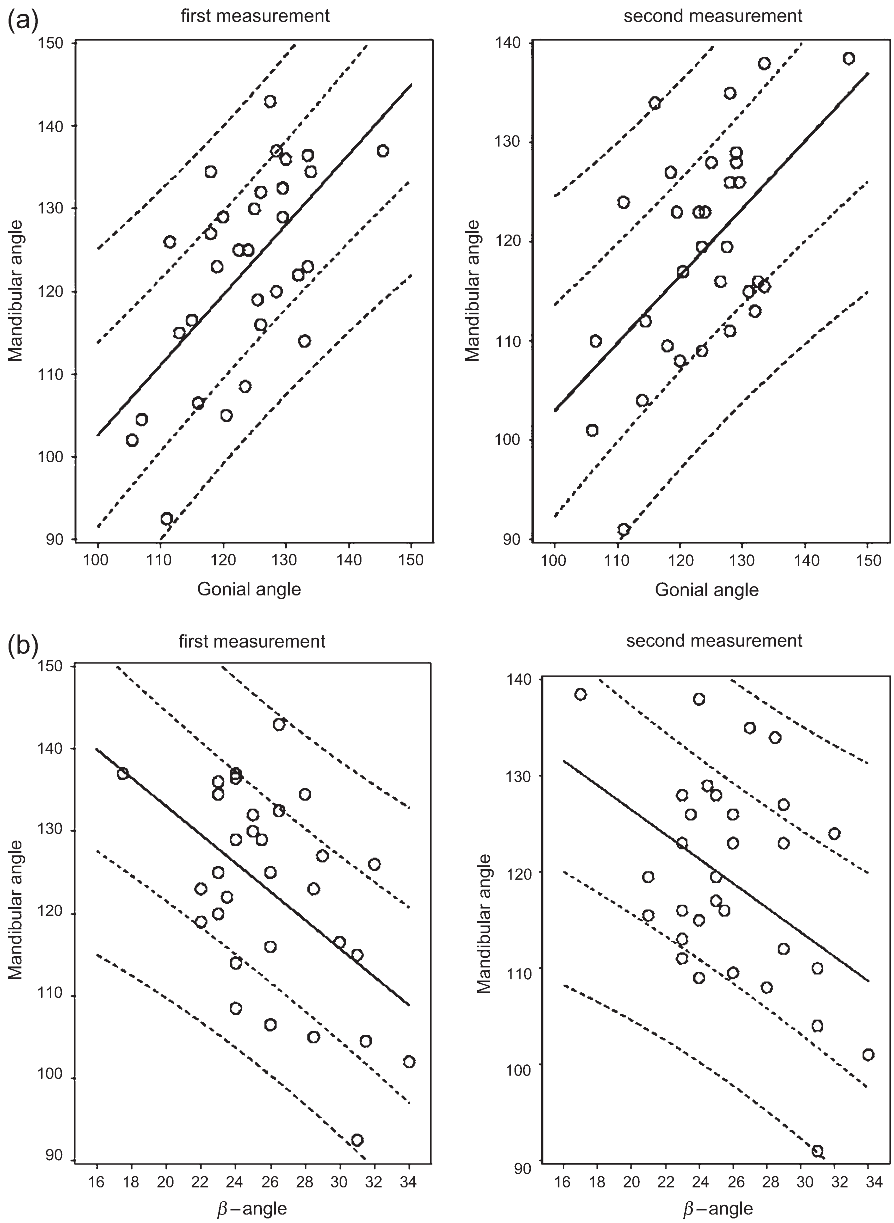

Figure 5 Graphical illustration of correlation between the outer and inner mandibular morphology and gonial (a) and β (b) angles.

was −0.60, $P = 0.0004$. When the mental angle was wide or wider than the average, the mandibular angle tended to be narrow or narrower than the average. When the mental angle was narrow, the mandibular angle tended to be wide (Figure 4).

Inner and outer morphology

With regard to internal and external mandibular morphology, a statistical correlation was found only between the mandibular and gonial angles (Figure 5a). The correlation coefficient was 0.57, $P = 0.0009$. A wide or narrow gonial angle corresponded with a wide or narrow mandibular

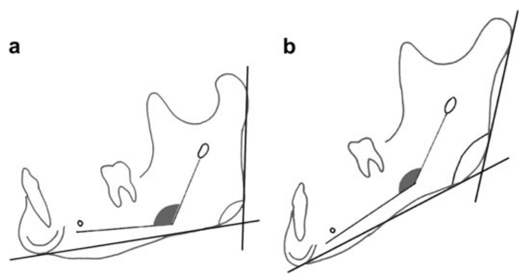

Figure 6 Drawings of two human mandibles illustrating the relationship between the outer gonial and inner mandibular angles. If the gonial angle is narrow, the mandibular angle has a tendency to be narrow (a). Conversely, if the gonial angle is wide, the mandibular angle tends to be wide (b).

angle. If the gonial angle was narrow, the mandibular angle tended to be narrow. Conversely, if the gonial angle was wide, the mandibular angle also tended to be wide (Figure 5).

A weaker correlation was found between the mandibular and β-angles, with a correlation coefficient of −0.39, $P = 0.029$ (Figure 5b). Close correlations were not found between inner and outer mandibular morphology (Figure 6).

Discussion

The aim of the present investigation was to analyse the correlation between the internal morphology, expressed by the two mandibular canals, and the external morphology of the human mandible. Apparently, no published studies have compared these structures. Previous research dealing with the mental foramen and the mental canal has compared these structures with different external references on the mandible, e.g. the dentition and the alveolar plane (Tebo and Telford, 1950; Warwick, 1950). These reference structures are unstable due to remodelling processes and differences in mandibular growth pattern and are therefore less suitable for evaluation. To obtain reliable results, the reference structures have to be stable during growth. Therefore, it is important to separate the external mandibular morphology from the internal morphology. The internal morphology of the mandible, i.e. the mandibular canal, is stable on a profile radiograph, whereas the external morphology is not (Björk, 1969).

In the present study, a line was drawn parallel with the first centimetre from the mandibular foramen on the prints of the radiographs. The reason for this was that this part of the mandibular canal is developed post-natally (Chavez-Lomeli *et al.*, 1996). Another reference line was drawn on the first centimetre of the mandibular canal close to the mental canal because this part of the mandibular canal is developed pre-natally (Kjær, 1989). This line was the most difficult to place since the contour of the mandibular canal is not as distinct in this region as it is close to the mandibular foramen. Another problem was that the mental canal was not visible on profile radiographs without insertion of a pin. The mental canal develops post-natally by apposition (Kjær, 1989). It is therefore presumed that the post-natally developed parts of the mandibular canal and the mental canal reflect the mandibular growth pattern. This was confirmed in the present study.

The finding of a relationship between the mandibular angle and the gonial angle supports the rotational pattern of the mandible identified by Björk and Skieller (1983).

Conclusion

The findings of this study showed that the morphology of the mandibular canal and the angulation between the mandibular and mental canals reflect the outer morphology and growth pattern of the mandible in normal cases. It is suggested that the morphology of the mental and mandibular canals and the angulation between parts of the canals are included in orthodontic and anthropological evaluation of normal and pathological mandibles.

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