Cephalometric investigation of craniomaxillofacial structures during the prenatal period: A cadaver study

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Introduction: We aimed to investigate the morphometric development of the cranial base and its related structures, and their growth rate changes from the ninth gestational week to full term in a large group of human fetuses. **Methods:** We selected 203 (109 male, 94 female) fetuses between 9 and 40 weeks of gestation and without any external anomalies. From each fetus, standard lateral and posteroanterior cephalometric images were taken using a dental digital panoramic and cephalometric x-ray machine. Fourteen linear and 9 angular parameters were measured. **Results:** The cranial base angle showed a statistically significant increase between the groups from only the second to the third trimester periods. The sagittal translation of the maxilla increased during the prenatal period, whereas the mandibular sagittal relation grew at a steady rate. The vertical plane angles of the maxilla and the mandible did not show any significant changes. The maxillary length to mandibular length ratio remained stable. **Conclusions:** The cranial base angle increased, especially in the second through the third trimesters. The maxilla and the mandible demonstrated different growth patterns in the sagittal direction. The findings of this study could be a guide for interpreting the relationships among the craniofacial structures. (Am J Orthod Dentofacial Orthop 2014;145:217-27)

Successful orthodontic diagnosis, treatment planning, and clinical procedures require a thorough understanding of growth and development.[1] The prevention, interception, and correction of dentofacial deformities also depend largely on a proper understanding of craniofacial growth and development. The craniofacial region is a dynamic biologic continuum that begins in embryonic development and continues through senility,[2] and its growth patterns are even more complex.[1] The greatest changes in the proportions of the postnatal skull are those that take place in the dentofacial region, especially the jaws. The morphometric changes in this region are a challenge because all parts of the cranial and facial bones grow at different rates and in different directions.[1,3]

The importance of craniofacial growth before birth and its relevance postnatally have been reported previously.[4] Prenatal development sheds light on postnatal development. The etiologic factors responsible for some positional abnormalities of the maxilla and the mandible are also related to their embryonic fetal development.[5,6] Studies of prenatal craniofacial growth, especially during the last 2 trimesters, have also shown growth patterns that are similar to postnatal craniofacial growth.[2,7]

In previous studies, morphometric measurements of the craniofacial region during the prenatal period were carried out either anatomically on cadavers or by ultrasound on pregnant women.[8-10] Cephalometric growth studies have been devoted almost exclusively to the period from birth to adulthood. Little radiographic work has been done on fetus cadavers. Rabkin[11] studied 125 embryos and fetuses up to 6 months old. He reported that the skeletal structure and morphology of the jaws have an inherent predetermined pattern in the embryo-fetal life of each person. Ford[12] analyzed 76 fetuses from 10 to 40 weeks of age. By means of linear measurements, he demonstrated changes in width, height, and depth as a result of

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, December 2012; revised and accepted, September 2013.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2013.09.014

differential growth rates of the fetal skull. However, most studies on the prenatal period are limited to a certain number of gestational weeks or have limited samples. Kjaer[13] argued that malformations of any cranial region or the dentition affect all craniofacial tissues, and that there is a need for prenatal autopsy studies to advance fetopathology and the understanding of postnatal development. Therefore, we aimed to investigate the development of the cranial base and its related facial structures and to determine their growth rate changes from 9 weeks until full term in a large series of human fetuses using the cephalometric method.

MATERIAL AND METHODS

In this study, a collection of 335 human fetus cadavers was examined. All fetuses resulting from spontaneous or legally induced abortions were collected between 1997 and 2010 in the Isparta province of southwestern Turkey. Thorax and abdomen autopsies were made, and fetuses with any organ anomalies or external malformations were excluded from the study. We obtained 232 fetus cadavers, with approval from the parents. The fetuses were between 9 and 40 weeks of gestation and had no external anomalies. Eighteen fetuses were excluded because of deformations in the craniofacial region. During the radiographic measurements, 11 fetuses were excluded because of the lack of accurate anatomic landmarks. Moreover, in 7 fetuses, measurements related to nasion and sella were not recorded at the ninth and tenth gestational weeks because they could not be accurately determined radiographically. Consequently, 203 fetuses (109 male, 94 female) were used for the study. Written consent from the families, permission from the Ministry of Health of Turkey, and ethical approval from the board of the faculty of medicine of the University of Süleyman Demirel were obtained before the study. The fetuses were fixed in 10% formaldehyde.

The gestational ages of the fetuses were determined according to general parameters (crown-rump length, biparietal diameter, head circumference, femur length, and foot length) between weeks 9 and 40[14] (Table I).

General parameters were the following: (1) crown-rump length, the vertical length between 2 planes passing through the vertex and lowermost point of the rump; (2) head circumference, circumferential line passing through glabella, parietal tubers, and inion (external occipital protuberance); (3) biparietal diameter, transverse length between parietal tubers; (4) femur length, vertical length between the tip of the greater trochanter and the midpoint of the knee joint; and (5) foot length, length between the posteriormost point of the heel and the anteriormost point of the toes.

Table I. Means (mm) of the external general parameters of the fetuses with regard to gestational weeks

Gestational age (wk)	*n*	*Crown-rump length*	*Head circumference*	*Biparietal diamater*	*Femur length*	*Foot length*
9	4	65	60	15	13	8
10	2	68	67	16	13	9
11	3	84	81	17	20	12
12	4	90	84	22	21	12
13	6	94	97	24	21	14
14	7	105	97	25	25	16
15	6	107	114	31	29	18
16	12	121	122	33	31	21
17	15	126	132	36	35	22
18	10	144	146	39	38	26
19	8	152	159	41	41	29
20	9	159	170	46	44	31
21	8	167	183	49	49	34
22	6	185	203	55	51	37
23	7	187	210	55	54	39
24	8	199	218	57	60	43
25	10	206	228	58	61	44
26	6	207	234	60	64	46
27	6	233	247	64	65	54
28	4	237	267	66	70	55
29	4	245	273	67	73	55
30	6	252	275	71	72	56
31	5	263	281	74	73	59
32	3	266	292	76	76	60
33	6	266	295	77	79	62
34	3	267	301	77	79	63
35	3	278	305	78	85	68
36	7	292	323	80	89	72
37	5	294	338	93	91	72
38	6	302	349	93	96	74
39	3	312	353	96	97	77
40	11	328	363	95	99	78

The fetuses were divided into 8 groups according to gestational months (9-12 weeks, third month; 13-16 weeks, fourth month; 17-20 weeks, fifth month; 21-24 weeks, sixth month; 25-28 weeks, seventh month; 29-32 weeks, eighth month; 33-36 weeks, ninth month; and 37-40 weeks, tenth month). They were also divided into 4 groups according to trimester. Fetuses aged 9 to 13, 13 to 25, 26 to 37, and 38 to 40 weeks were allocated into groups I (first trimester), II (second trimester), III (third trimester), and IV (full term), respectively.

Lateral and posteroanterior cephalometric images were taken of each fetus using a dental digital panoramic and cephalometric x-ray machine (Pax-400C; Vatech Co Ltd, Gyeonggi-Do, Korea). All fetuses were placed in a standard vertical position using cephalostat rods. Radiation doses were adjusted in a range of 40 to 70 kV and 3 to 8 mA according to gestational weeks. The film-to-focal spot distance was 160 cm. Fourteen