Analysis of mandibular dimensions growth at different fetal ages

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Abstract

Objective: To investigate growth asymmetry between the left and right hemimandibles (HMs) during the 2nd and early 3rd trimester of pregnancy. **Methods:** Sixty eight hemimandibles (34 mandibles) of fetuses were used—20 female and 14 male—preserved in 10% formalin solution, and the following measurements were performed: Condyle-Coronoid Process (Co-CP), Gonion-Coronoid Process (Go-CP), Gonion-Gnathion (Go-Gn), Condyle-Gnathion (Co-Gn), Symphyseal Height (SH), Mandibular Angle (MA). The data were collected, tabulated and analyzed with the aid of SPSS software, version 11.0, 2005. One-way ANOVA test was performed to compare the mean values of anatomical measurements of the right and left HMs. Gestational ages were divided into second trimester (Period 1: 13-18 weeks and Period 2: 18-24 weeks), and early third trimester (Period 3: 24-30 weeks) of pregnancy. **Results:** We noted a slight growth rate asymmetry in Go-Gn, Co-CP, Co-Gn, Go-CP and SH, comparing the left and right mandibular halves, between the 2nd and early 3rd trimester of pregnancy, although not statistically significant ($p > 0.05$). It was also found that the mandibular angle decreased and showed a slight—though statistically significant ($p < 0.05$)—asymmetry in the same prenatal period. **Conclusion:** The authors concluded that there was a slight asymmetry in the growth rate of measurements Go-Gn, Co-CP, Co-Gn, Go-CP and SH, comparing the left with the right hemimandible between the 2nd and early 3rd trimester of gestation.

Keywords: Growth. Mandible. Fetus.

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INTRODUCTION

The mandible appears in adults as a single bone. However, various portions or subunits are found during its development process: the body of the mandible, to which the alveolar portion is attached, the condylar and coronoid processes, mandibular angles and mentum.[3]

The facial development process begins from the first and second pharyngeal arches during the fourth week of gestation.[9] Proffit[10] asserted that the first pharyngeal arch, also called mandibular arch, gives rise to tissues that will develop in the masticatory muscles and mandible. The mandibular arch houses Meckel's cartilage, which is responsible for its support. The mandibular body originates in the anterior portion of Meckel's cartilage from the intramembranous ossification of the ventral portion of the first branchial arch. The mandibular condyle, in turn, starts its development from a secondary cartilage, which is covered with a fibrous capsule.[10] According to Moyers,[9] mandibular dimensions show different growth patterns during the prenatal period and after birth.

It was long believed that the condyle was the center of mandibular growth.[3] With the advent of Functional Matrix Theory, however, a number of theories emerged addressing bone structure growth and development.[8] The condyle undoubtedly plays a major role in mandibular growth but it is not alone since mandibular growth is a complex process that cannot be explained away in simplistic terms.[3]

Research on fetal mandibular growth basically correlates the development of mandibular structures with fetus age.[1,4,5,16]

In his study, Mandarim et al[6] provided a straightforward and accurate method for classifying fetal age. Once the values of certain parameters are known—such as growth of cephalic module, greater foot length, crown-rump length, and weight—it is possible to determine fetal age. They used a table initially proposed by Streeter,[17] which was perfected by the authors and helps determine such an age in weeks post conception with reasonable approximation.[6]

The work of Mandarim et al[6] was rectified and showed a correlation between foot length and the growth in crown-rump length.[14]

Studying the mandible during the prenatal period is critical for the evaluation and diagnosis of congenital anomalies of the face, whereas mandibular abnormalities may be associated with several syndromes.[1,4,5,7,12] Thus, data from this study may contribute to a better understanding of the process of formation and development of the facial skeleton.[13]

The purpose of this study is to provide a comparison between different anatomical dimensions of the right and left hemimandibles (HMs) during the second and early third trimester of pregnancy.

Ultrasound methods, when used to assess mandibular growth structures and for the diagnosis of fetal malformations such as micrognathia and macrognathia, establish evaluation criteria for the diagnosis of mandibular anomalies *in uterus*, which allows early diagnosis and the choice of a suitable therapy.[12] Research has emphasized that any structural changes in mandibular cartilage during the prenatal period are more intimately related to local mechanical factors and articulation than to bone growth *per se*.[12]

The functions exerted by the masseter and temporal muscles induce mandibular growth during the 11th week.[1]

MATERIAL AND METHODS

Were used 68 HMs (34 mandibles) of fetuses—20 female and 14 male—preserved in 10% formalin solution. The fetuses, supplied by the Department of Morphology, Juiz de Fora Federal University, were Brazilian and presented with no malformation whatsoever. The study was preapproved by the Ethics Committee of the Juiz de Fora Federal University.

Gestational age ranged from 13 to 30 weeks post-conception (WPC) and was estimated on the basis of greatest foot length and weight, according to protocol[5,6,16] (Table 1).

After the fetal age had been estimated, the mandibles were dissected, disjointed and immersed in a plastic 50 x 50 x 80 cm wash tub containing water. The technique of natural running water maceration was utilized.[12] It took a period of 6 weeks for the complete removal of the soft tissues, including the periosteum, for better visualization of the anatomical landmarks chosen for analysis. After this process, the following measurements[5] were performed (Fig 1):

1. Condyle-Coronoid Process (Co-CP): Distance between the posterior-most point on the condylar process and the anterior-most point on the coronoid process.

2. Gonion-Coronoid Process (Go-CP): Distance between the gonion and the upper-most

TABLE 1 - Gestational age according to the criteria of greatest foot length and weight.

AGE (WPC)	GENDER	WEIGHT (g)	GREATER FOOT LENGTH (mm)	Co-CP (cm)	Go-CP (cm)	SH (cm)	Go-Gn (cm)	Co-Gn (cm)	MA	HM
13.4	F	68.2	18	0.555	0.755	0.425	1.115	1.765	148°	R
				0.565	0.775	0.400	1.100	1.725	153°	L
13.7	M	61.5	19	0.575	0.710	0.365	1.055	1.685	157°	R
				0.525	0.715	0.365	1.075	1.645	140°	L
13.7	M	75.2	19	0.545	0.800	0.415	1.055	1.825	153°	R
				0.565	0.785	0.400	1.000	1.835	155°	L
15.2	F	131.3	24	0.675	0.955	0.385	1.525	2.155	138°	R
				0.685	1.000	0.385	1.575	2.155	142°	L
15.2	F	137.3	24	0.645	0.725	0.415	1.500	2.185	149°	R
				0.635	0.775	0.400	1.500	2.085	150°	L
15.7	M	127.9	26	0.865	0.875	0.445	1.425	2.200	153°	R
				0.855	0.900	0.445	1.455	2.335	155°	L
17.4	F	194.8	32	0.865	1.115	0.635	2.025	2.700	146°	R
				0.865	1.115	0.635	2.025	2.700	146°	L
17.4	F	224.1	32	0.775	1.035	0.535	1.685	2.435	148°	R
				0.785	1.045	0.535	1.585	2.415	148°	L
17.8	F	212.5	33	0.675	1.055	0.500	1.800	2.385	144°	R
				0.700	1.035	0.500	1.825	2.400	144°	L
18.1	M	333.7	34	0.835	1.185	0.645	2.085	2.715	141°	R
				0.825	1.165	0.645	2.035	2.735	136°	L
18.1	F	201.7	34	0.775	1.045	0.600	1.945	2.675	153°	R
				0.775	1.100	0.600	1.965	2.665	146°	L
18.4	M	287.7	35	0.795	0.995	0.615	1.925	2.800	147°	R
				0.815	1.025	0.575	2.000	2.785	145°	L
18.4	F	292.8	35	0.825	1.085	0.535	1.975	2.615	148°	R
				0.900	1.165	0.535	1.945	2.645	146°	L

18.7	M	309.6	36	0.865	1.085	0.585	1.995	2.700	148°	R
				0.895	1.245	0.575	1.965	2.775	151°	L
19.0	M	320.3	37	0.955	1.100	0.555	2.145	2.775	142°	R
				0.925	1.135	0.565	2.165	2.800	148°	L
19.0	F	319.2	37	0.775	1.145	0.525	2.165	2.765	141°	R
				0.755	1.045	0.495	2.225	2.765	132°	L
19.0	F	387.2	37	0.915	1.265	0.545	1.945	2.915	140°	R
				1.000	1.245	0.545	2.055	2.915	130°	L
20.5	F	418.5	42	0.885	1.165	0.555	2.100	2.785	140°	R
				0.825	1.125	0.555	2.100	2.800	135°	L
20.9	F	459.5	43	0.925	1.275	0.665	2.525	3.055	127°	R
				0.935	1.295	0.665	2.500	3.075	130°	L
21.3	M	477.8	44	0.945	1.315	0.735	2.265	3.000	140°	R
				0.875	1.335	0.735	2.275	2.845	138°	L
21.8	F	462.3	45	1.000	1.425	0.855	2.465	3.235	134°	R
				1.015	1.435	0.855	2.465	3.235	131°	L
21.8	M	535.5	45	1.025	1.445	0.700	2.600	3.400	144°	R
				1.055	1.400	0.665	2.615	3.355	140°	L
21.8	F	541.5	45	1.165	1.500	0.845	2.620	3.455	145°	R
				1.100	1.555	0.800	2.655	3.445	148°	L
22.2	F	507.3	46	1.255	1.165	0.665	2.515	3.425	147°	R
				1.145	1.335	0.665	2.445	3.395	147°	L
23.1	M	657.1	48	1.025	1.245	0.800	2.485	3.425	137°	R
				1.035	1.225	0.800	2.475	3.425	148°	L
24.8	F	699.0	52	1.115	1.325	0.675	2.735	3.475	139°	R
				1.175	1.335	0.685	2.725	3.500	138°	L
25.7	M	628.7	54	1.085	1.615	0.965	2.565	3.675	136°	R
				1.100	1.745	0.965	2.600	3.535	138°	L
27.1	M	1956.3	43	1.555	1.875	1.315	3.645	4.915	138°	R
				1.600	2.055	1.300	3.655	4.975	141°	L
27.5	M	1166.4	58	1.275	1.565	1.135	3.135	4.215	151°	R
				1.245	1.600	1.100	3.075	4.075	141°	L
27.6	F	1303.0	60	1.455	1.525	1.045	2.775	4.085	142°	R
				1.465	1.625	1.045	2.745	4.115	150°	L
28.0	F	1560.4	61	1.600	1.715	1.155	3.265	4.425	147°	R
				1.715	1.685	1.100	3.225	4.500	150°	L
28.0	F	995.8	59	1.400	1.500	0.955	2.995	4.000	149°	R
				1.345	1.445	1.965	3.075	3.965	140°	L
28.9	F	1223.7	63	1.300	1.585	0.975	2.655	4.035	147°	R
				1.305	1.575	0.975	2.660	4.055	148°	L
30.3	M	30.3	66	1.500	1.665	0.965	2.865	4.100	144°	R
				1.500	1.765	0.935	2.885	4.275	144°	L

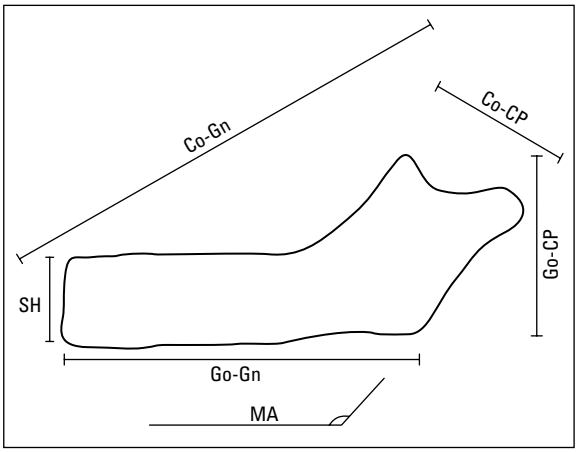

FIGURE 1 - Measurements performed in the hemimandible.

point on the coronoid process.

3. Gonion-Gnathion (Go-Gn): Length from Gonion to Gnathion.

4. Condyle-Gnathion (Co-Gn): Distance between the posterior-most point on the condylar process and the Gnathion.

5. Symphyseal height (SH): Measured on the median area to be occupied by the future central incisors, corresponding to the vertical distance between the upper-most and lower-most portions of the mandibular symphysis.

6. Mandibular Angle (MA): Measured between the posterior margin of the mandibular ramus and the lower margin of the mandibular body.

All measurements were made by one and the same author, using a 0.05 accuracy caliper and a digital scale. The extent of the mandibular angle was measured with the aid of a protractor (Table 1).

The data were collected, tabulated and analyzed with the aid of SPSS software, version 11.0, 2005 (Statistical Package for the Social Sciences, SPSS Inc., USA). One-way ANOVA test was performed to compare the mean values of anatomical measurements of the right and left HMs. Gestational age was divided into Period 1 (13-18 WPC), Period 2 (18-24 WPC), and Period 3 (24-30 WPC). Level of significance was set at $p < 0.05$.

RESULTS

An analysis of the following data was conducted for all measurements using 5% statistical significance:

Go-CP, Go-Gn, Co-Gn, and Co-CP

A similar growth pattern emerged between the right and left HMs throughout the three periods. The left side exhibited a greater growth rate than the right, although not statistically significant (Figs 2, 3, 4 and 5, respectively).

SH (Symphyseal Height)

A similar growth pattern emerged between the right and left HMs throughout the three periods. The right side had a higher growth rate than the left, although not significant $p > 0.05$ (Fig 6).

MA (Mandibular Angle)

We observed a different growth pattern between periods 1 and 2 and between periods 2 and 3. The mandibular angle of the left HM underwent a greater decrease than the right side between the first and second periods and a greater increase between the second and third periods. When the first and third periods were compared, however, both HMs were found to be identical. These results showed statistical significance ($p < 0.05$) and support the findings of the Malas et al[6] study, in which significant differences were found between the right and left sides (Fig 7).

Mandibular Body x Mandibular Ramus

Mandibular body growth (length: Go-Gn, height: SH) was higher than that of the mandibular ramus (length: Co-CP, height: Go-CP) from first to third period. The highest growth rate was found for mandibular body height (SH) (Table 2).

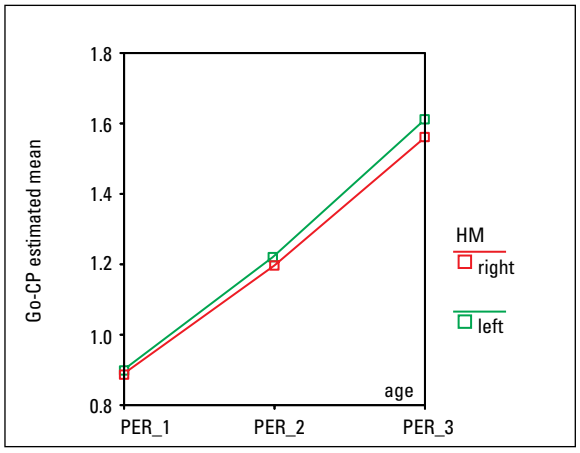

FIGURE 2 - Go-CP estimated means.

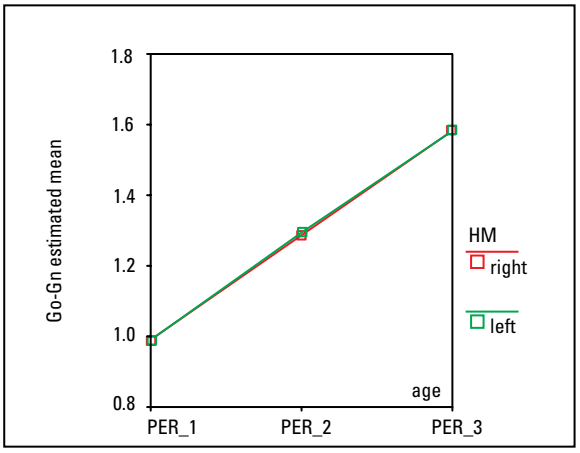

FIGURE 3 - Go-Gn estimated means.

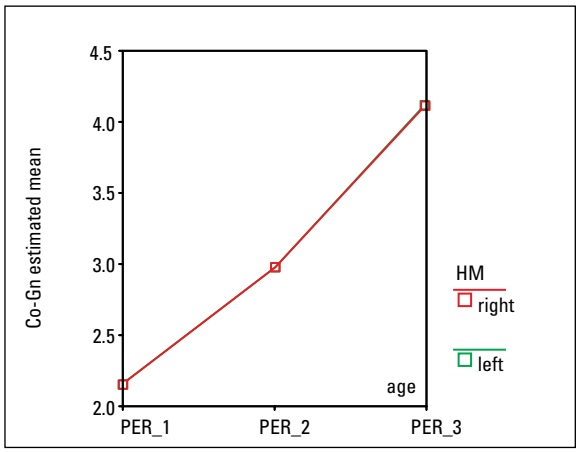

FIGURE 4 - Co-Gn estimated means.

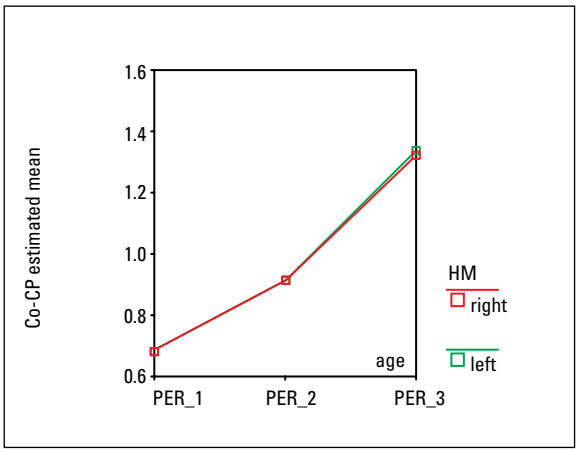

FIGURE 5 - Co-CP estimated means.

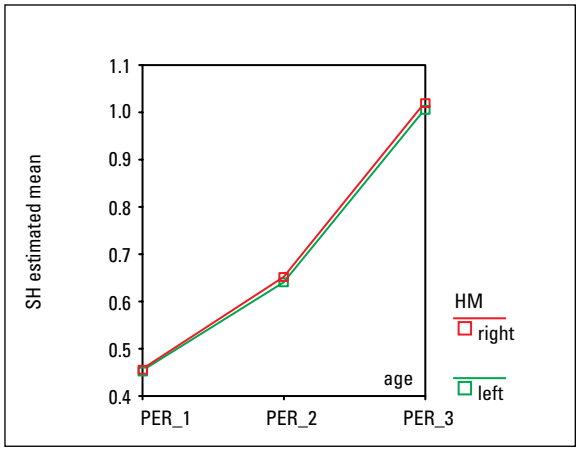

FIGURE 6 - SH estimated means.

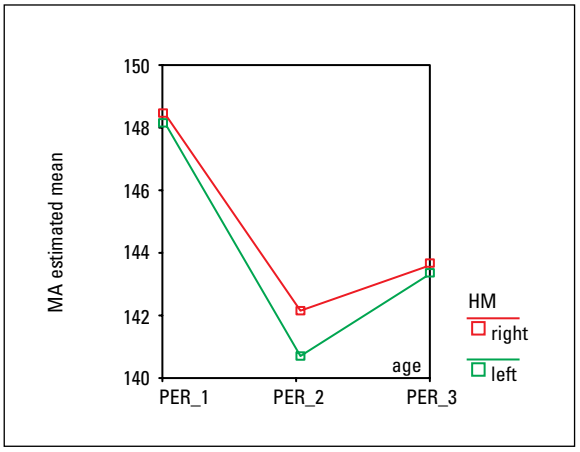

FIGURE 7 - MA estimated means.

TABLE 2 - Growth of mandibular body and ramus.

MEASUREMENT	AGE	HM MEAN	AMOUNT OF HM	GROWTH IN PERCENTAGE PER PERIODS
Co-CP	PER_1	0.68639	18	PER_1 - PER _2: 35.40%
	PER_2	0.92938	32	PER_2 - PER_3: 47.83%
	PER_3	1.37389	18	PER_1 - PER_3: 100.16%
Go-CP	PER_1	0.89833	18	PER_1 - PER _2: 36.61%
	PER_2	1.22719	32	PER_2 - PER_3: 32.19%
	PER_3	1.62222	18	PER_1 - PER_3: 80.58%
SH	PER_1	0.45472	18	PER_1 - PER _2: 42.26%
	PER_2	0.64688	32	PER_2 - PER_3: 56.78%
	PER_3	1.01417	18	PER_1 - PER_3: 123.03%
Go-Gn	PER_1	1.46250	18	PER_1 - PER _2: 52.47%
	PER_2	2.22938	32	PER_2 - PER_3: 32.77%
	PER_3	2.96000	18	PER_1 - PER_3: 102.39%

DISCUSSION

In pathological conditions mandibular measurements can vary and alter the mandibular angle, which can lead to malocclusion and orthodontic problems in adults.[8]

In some studies, researchers found variations and decreased values of the condylar angle as the gestational period evolved.[1,2,13,15] A study of the mandibular angle of 162 fetuses between 9 and 40 WPC showed that the mean values were 122±8° with no significant differences between trimesters nor between left and right HMs.[7] In another study, the observed mean of 139±1° in 36 fetuses between 13 and 37 WPC showed no significant changes in the angle during the second and third trimesters of pregnancy, comparing the right with the left HM.[5] In our study, we noted a variation in the mean value of the mandibular angle (143±6°) between 13 and 30 WPC. There was a decrease during the second quarter and an increase early in the third trimester, more pronounced on left side ($p < 0.05$). But when we compared the mean values at the beginning and end of the period studied, we found no significant differences ($p > 0.05$). Previous studies report that mastication causes a decrease in the mandibular angle between birth and adult life.[3,8,9] This suggests that the mandibular angle does not complete its development in the intrauterine period but throughout childhood, puberty and early adulthood and is influenced by mechanical factors.

A radiographic study of mandibular growth using 19 fetal mandibles aged between 18 and 41 WPC showed that the total length of the mandible (Co-Gn) and mandibular body (Go-Gn) increases linearly with fetal age.[2] We found similar results in the present study since the Co-Gn and Go-Gn measurements indicated a slightly greater growth pattern in the left HM, although not statistically significant ($p > 0.05$).

A literature review disclosed contrasting results. During the 2nd and 3rd trimester of prenatal life mandibular growth is allometric.

The mandibular body grows more rapidly than the ramus, both in length (Go-Gn) and height (SH) while symphysis height displays the highest growth rate.[5] According to some authors, however, the mandibular ramus grows faster than the mandibular body, both in length (Co-CP) and height (Go-CP),[2,3] and ramus height shows the fastest growth rate.[2,3] In this study, we found a greater growth rate in the height (SH) and length of the mandibular body (Go-Gn) compared with the length (Co-CP) and height of the mandibular ramus (Go-CP), as shown in Table 2.

Mandibular dimensions (Go-CP and SH) were assessed using multivariate analysis and PCA and revealed higher growth rates on the right side.[5] All other measurements (Co-CP, Go-Gn, Co-Gn, MA) showed a higher growth rate on the left side, between 13 and 37 weeks of gestation.[5] In our study, an analysis of graphs reflecting the mean measurement values showed agreement with those values, except for Go-CP, which showed a growth rate slightly higher in the left HM.

CONCLUSION

The authors concluded that there was a slight asymmetry in the growth rate of measurements Gn-Go, Co-CP, Co-Gn, Go-CP and SH, comparing the left with the right hemimandible between the 2nd and early 3rd trimester of gestation, although not statistically significant. Furthermore, a reduction was found in the mandibular angle (MA) during the 2nd trimester of gestation, which contrasted with an increased MA at the beginning of the 3rd trimester, in addition to a slight asymmetry. These findings showed statistical significance.

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