

A determination of the standards of morphometrics variables of the stomatognathic system of a fetus

Salaga-Nefic, Samra¹; Mehmedbasic, Senad²; Kozadra, Jasmina³; Zukanovic, Amila³; Tiro, Alisa³; Dzemidzic, Vildana³; Nakas, Enita³

¹ Private Private Dental Practice, Switzerland

² Institute for Gynecology, Perinatology and Infertility, BiH

³ University of Sarajevo, Sarajevo

ABSTRACT

Introduction: Many factors affect the growth and development of the mandible. The most common one is micrognathia; this can pose and neonatal emergency. Early recognition of mandibular and other face anomalies could provide immediate care for these infants, and presence of neonatologist or other doctors in the delivery room.

The aim: Aim of this study was to develop normal ranges of the facial markers: mandibular length, jaw index and the facial angle in the fetus using 3D ultrasound.

Material and methods: The research was conducted as a cross-sectional study in the second trimester of pregnancy. Fetuses (female n=23 and male n=27) from singleton pregnancy between 29-37 week of gestation were examined by ultrasound. All images were acquired transabdominally, using Voluson E16. Ultrasound was performed by an experienced operator (SM) and measured the values of head circumference, abdominal circumference, biparietal diameter, femur length, body mass. For mandibular length, inferior facial angle, and the jaw index was calculated ($\text{Jaw Index} = \text{AP mandibular diameter} / \text{BPD} * 100$), the profile images were used (only images in the exact midsagittal plane were used). The characteristics of the fetal profiles were determined by the Schwartz and Ricketts profile analysis using soft tissue landmarks and analysis of the profile photographs.

Results: The results show that the jaw index ranged from 25.33 and 34.06 with an average of 26.00 for all examined fetuses.

Conclusion: The physiological position of the mandible is retrognathic and that the average physiological length of the mandible in the third trimester is 2.31cm. There is no difference in mandibular length between genders.

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INTRODUCTION

Many factors affect the growth and development of the mandible: genes, irregular cell migration, low growth potential, feeding habits, and other habits acquired by newborns.¹ The most common anomalies are microgenia (weak mandible growth) and retrogenia (small mandible growth in the sagittal plane).¹ Deviation of physiological mandibular growth and development may incapacitate the essential functions of the stomatognathic system. Fetuses with mandible anomalies are at risk of airway obstruction through retro-positioning of the tongue-base into posterior pharyngeal airway.² Micrognathia is

frequently seen in Pierre Robin sequence, however it can be found in many genetic syndromes.³

Antenatal diagnosis of anomalies by ultrasound is widely used nowadays.

The aim of this study was to develop normal ranges of the facial marker: mandibular length, jaw index and the facial angle in the fetus using 3D ultrasound.

MATERIAL AND METHODS

The research was conducted as a cross-sectional study in the second trimester of pregnancy. Fetuses (female n=23 and male n=27) from singleton pregnancy between 29-37 week of gestation were examined by ultrasound. All images were acquired transabdominally, using ultrasound Voluson E16, GE Healthcare, Austria GmbH & Co OG.

Corresponding Author:

Samra Salga-Nefic

Rosenweg 2a, 3125 Toffen, Switzerland,

e-mail: samrasalaga@gmail.com

Parameters and measurements:

Ultrasound was performed by an experienced operator (SM) and measured the values of head circumference, abdominal circumference, biparietal diameter, femur length, body mass. For mandibular length, inferior facial angle, and the jaw index was calculated (Jaw Index = AP mandibular diameter / BPD * 100). The profile images in the exact midsagittal plane were used. The characteristics of the fetal profiles were determined by the Schwartz and Ricketts profile analysis using soft tissue landmarks and analysis of the profile photographs. The profile was analyzed using the Schwarz and Ricketts method. The

positions of four soft tissue landmarks: the tip of the upper lip, lower lip, skin pogonion, and subnasale were compared to three lines: the Dreyfus line, Simon line, and the E-line. A positive value indicates that the landmark is anterior to the line and a negative value indicates that the landmark is posterior to the line. Each measurement was evaluated twice, and the mean value was used as relevant.

RESULTS

Table 1 shows measured values of fetal development parameters between the 29th and 37th gestational week.

Table 1. Distribution of fetal development parameters

GW		HC	BPd	FL	AC	BM	ML	IFA	JI
29	Mean	25.300	7.500	6.060	22.520	1203.000	1.900	47.500	25.330
	Standard error of Mean								
	Standard Deviation								
30	Mean	29.277	8.233	6.137	27.263	1923.000	2.000	52.167	24.290
	Standard error of Mean	0.617	0.077	0.119	0.252	15.100	0.000	1.424	0.230
	Standard Deviation	1.068	0.133	0.206	0.437	26.153	0.000	2.466	0.398
32	Mean	29.127	8.392	6.080	27.444	2035.333	1.994	56.500	23.978
	Standard error of Mean	0.535	0.101	0.201	0.582	109.301	0.102	3.639	1.163
	Standard Deviation	1.606	0.304	0.604	1.746	327.904	0.307	10.917	3.489
33	Mean	29.499	8.563	6.350	28.609	2231.667	2.356	58.056	27.502
	Standard error of Mean	0.318	0.153	0.081	0.458	111.675	0.146	3.269	1.939
	Standard Deviation	0.953	0.459	0.244	1.374	335.025	0.438	9.806	5.817
34	Mean	31.010	9.255	6.804	30.105	2655.625	2.000	60.938	21.538
	Standard error of Mean	0.174	0.011	0.035	0.055	23.125	0.000	0.979	0.053
	Standard Deviation	0.493	0.032	0.099	0.154	65.408	0.000	2.770	0.150
35	Mean	31.528	9.068	6.925	31.623	2873.500	2.775	55.833	30.596
	Standard error of Mean	0.052	0.008	0.017	0.020	2.513	0.017	0.691	0.174
	Standard Deviation	0.126	0.019	0.042	0.050	6.156	0.042	1.693	0.427
36	Mean	31.517	9.360	7.026	30.316	2777.300	2.305	41.300	24.619
	Standard error of Mean	0.340	0.046	0.039	0.187	30.093	0.032	0.611	0.285
	Standard Deviation	1.074	0.145	0.124	0.593	95.163	0.101	1.932	0.903
37	Mean	32.315	9.263	7.125	31.910	3071.500	3.156	48.750	34.069
	Standard error of Mean	0.151	0.063	0.039	0.477	86.195	0.026	0.924	0.160
	Standard Deviation	0.302	0.125	0.079	0.953	172.390	0.052	1.848	0.320

GW - Gestational Week, *HC* - Head Circumferences, *BPd* - Biparietal diameter, *FL* - Femur Length, *AC* - Abdominal Circumferences, *BM* - Body Mass, *ML* - Mandibular Length, *IFA* - Inferior Facial Angle, *JI* - Jaw Index

Table 2 shows the measurements of the mandibular length correlated with the habits as follow. There is no correlation

between the habits of the pregnant women, the gender of the fetus and the value of the mandibular length.

Table 2. Measurements of Mandibular Length cross-referenced with the habits of the mothers

		Count	Minimum	Maximum	Range	Mean	Median	Standard deviation	Variance
Question	Answer	50	1.6	3.4	1.8	2.31	2.23	0.42	0.18
Did the mother consume tobacco?	Yes	14	1.6	3.4	1.8	2.28	2.23	0.49	0.24
	No	36	1.8	3.225	1.425	2.32	2.23	0.40	0.16
Did the mother consume alcohol?	Yes	1	2.5	2.5	0	2.50	2.50		
	No	49	1.6	3.4	1.8	2.30	2.20	0.42	0.18
Did the mother consume narcotics?	Yes	3	2.2	2.8	0.6	2.42	2.25	0.33	0.11
	No	47	1.6	3.4	1.8	2.30	2.20	0.43	0.18
Does the mother have dental irregularity?	Yes	17	1.8	3.15	1.35	2.27	2.20	0.37	0.14
	No	33	1.6	3.4	1.8	2.33	2.25	0.45	0.20
Did the mother consume supplements?	Yes	25	1.6	3.15	1.55	2.31	2.25	0.38	0.14
	No	25	1.65	3.4	1.75	2.30	2.10	0.47	0.22
Did the mother consume progesterone?	Yes	25	1.6	3.225	1.625	2.21	2.10	0.36	0.13
	No	25	1.65	3.4	1.75	2.41	2.30	0.46	0.22
Gender of fetus	Female	23	1.6	3.15	1.55	2.27	2.25	0.35	0.12
	Male	27	1.65	3.4	1.75	2.34	2.20	0.48	0.23

Table 3 shows the values of the inferior facial angle measured in this study compared with the habits. There is no correlation between the habits of the pregnant women, the gender of the

fetus and the value of the inferior facial angle. An average value of 53.3⁰ for a lower physiological minimum was defined in this study.

Table 3. Measurements of the Inferior Facial Angle

		Count	Minimum	Maximum	Range	Mean	Median	Standard deviation	Variance
Question	Answer	50	39	79	40	53.31	54.50	9.27	85.88
Did the mother consume tobacco?	Yes	14	41	79	38	57.14	57.75	11.40	130.05
	No	36	39	67.5	2805	51.82	51.00	7.98	63.76
Did the mother consume alcohol?	Yes	1	69	69	0	69.00	69.00		
	No	49	39	79	48	52.99	54.50	9.08	82.43
Did the mother consume narcotics?	Yes	3	41	59.5	18.5	51.83	55.00	9.65	93.08
	No	47	39	79	40	53.40	54.50	9.34	87.28
Does the mother have dental irregularity?	Yes	17	39.5	79	39.5	54.15	54.50	10.51	110.37
	No	33	39	74	35	52.88	54.50	8.70	75.75
Did the mother consume supplements?	Yes	25	39.5	79	39.5	52.92	54.50	10.52	110.66
	No	25	39	69	30	53.70	54.50	8.02	64.35
Did the mother consume progesterone?	Yes	25	39	74	35	51.40	51.00	9.96	99.29
	No	25	41	79	38	55.22	55.00	8.27	68.44
Gender of fetus	Female	23	39.5	79	39.5	54.24	54.50	11.35	128.91
	Male	27	39	64.5	25.5	52.52	54.50	7.17	51.36

The values of the jaw index obtained by the 50 fetuses were correlated with the habits and table 4 shows the results of measurements.

The results show that the jaw index ranged from 25.3 and 34.0 with an average of 26.0 for all examined fetuses. A correlation was found between the use of progesterone and the fetal jaw index (Mann-Whitney test is 186.000; $p < 0,05$). In fetuses where

the pregnant woman consumed progesterone, the value of the jaw index was smaller. A correlation was also found between the use of tobacco and the value of the jaw index (Mann-Whitney test is 247.500; $p < 0,05$). Fetuses whose mother did not consume tobacco had a smaller lower facial angle than in cases where the mother did consume tobacco.

Table 4. Measurements of Jaw Index

		Count	Minimum	Maximum	Range	Mean	Median	Standard deviation	Variance
Question	Answer	50	18.12	40.9	22.78	26.00	24.73	4.54	20.59
Did the mother consume tobacco?	Yes	14	18.12	40.9	22.78	26.17	24.84	5.82	33.82
	No	36	21.12	34.155	13.035	25.93	24.70	4.03	16.25
Did the mother consume alcohol?	Yes	1	29.45	29.45	0	29.45	29.45		
	No	49	18.12	40.9	22.78	25.93	24.70	4.56	20.77
Did the mother consume narcotics?	Yes	3	23.68	30.83	7.15	29.96	26.38	3.61	13.04
	No	47	18.12	40.9	22.78	25.94	24.70	4.62	21.30
Does the mother have dental irregularity?	Yes	17	21.12	34.42	13.3	25.70	24.50	4.05	16.39
	No	33	18.12	40.9	22.78	26.15	24.92	4.82	23.26
Did the mother consume supplements?	Yes	25	18.12	34.05	15.93	25.86	24.70	4.01	16.08
	No	25	21.12	40.9	19.78	26.14	24.81	5.09	25.92
Did the mother consume progesterone?	Yes	25	18.12	34.155	16.035	24.46	24.17	3.84	14.77
	No	25	21.12	40.9	19.78	27.53	26.38	4.73	22.36
Gender of fetus	Female	23	18.12	34.05	15.93	25.47	24.81	3.74	13.95
	Male	27	21.12	40.9	19.78	26.44	24.68	5.15	26.55

Table 5 shows the values of the body mass measured in this study compared with the habits. There is no correlation between

the body mass of the fetus and the habits of the pregnant woman and the gender of the fetus.

Table 5. Measurements of body mass

		Count	Minimum	Maximum	Range	Mean	Median	Standard deviation	Variance
Question	Answer	50	1203	3192	1989	2478.40	2683.00	458.82	210517.63
Did the mother consume tobacco?	Yes	14	1707	3128	1421	2397.00	2351.00	411.20	160085.54
	No	36	1203	3192	1989	2510.06	2690.00	477.75	228240.40
Did the mother consume alcohol?	Yes	1	2131	2131	0	2131.00	2131.00	-	-
	No	49	1203	3192	1989	2485.49	2685.00	460.80	212337.80
Did the mother consume narcotics?	Yes	3	2255	2879	624	2620.00	2726.00	325.22	105771.00
	No	47	1203	3192	1989	2469.36	2681.00	467.18	218257.19
Does the mother have dental irregularity?	Yes	17	1704	3128	1424	2375.29	2476.00	450.21	202692.22
	No	33	1203	3192	1989	2531.52	2685.00	460.93	212452.01
Did the mother consume supplements?	Yes	25	1716	3150	1434	2518.88	2695.00	411.14	169039.61
	No	25	1203	3192	1989	2437.92	2636.00	507.30	257353.41
Did the mother consume progesterone?	Yes	25	1704	3192	1488	2530.28	2685.00	411.54	169366.63
	No	25	1203	3128	1925	2426.52	2476.00	504.81	254832.84
Gender of fetus	Female	23	1704	3150	1446	2506.30	2685.00	404.34	163487.22
	Male	27	1203	3192	1989	2454.63	2675.00	507.08	257133.86

Analysis of the fetal profile measured the distances between soft tissue landmarks and three vertical lines. Table 6 shows the results of these measurements (all values measured in millimeters).

Table 6. The position of the four soft tissue landmarks in relation to the three vertical lines

	N	Mean	Standard deviation	Minimum	Maximum
Tip of the upper lip in relation to Dreyfus line	50	2.48	1.291	-1.00	5.00
Tip of the upper lip in relation to the Simon line	50	10.09	1.753	6.50	13.00
Tip of the upper lip in relation to the E line	50	0.99	1.699	-1.50	4.50
Tip of the lower lip in relation to Dreyfus line	50	-0.81	2.984	-6.00	4.00
Tip of the lower lip in relation to the Simon line	50	6.75	1.982	3.75	10.00
Tip of the lower lip in relation to the E line	50	0.58	1.646	-3.00	3.00
Sn in relation to Dreyfus line	50	1.25	1.125	-1.00	3.00
Sn in relation to the Simon line	50	9.04	1.397	5.25	11.00
Pg' in relation to Dreyfus line	50	-5.39	4.056	-11.00	8.00
Pg' in relation to the Simon line	50	2.19	3.032	-3.00	8.00

DISCUSSION

Intrauterine development is an intricate phenomenon that is explored in detail by many medical fields, including gynecologists, pediatricians, and orthodontists. For orthodontists, a fetal analysis may predict some future orthodontic anomalies. We began this research with an evaluation of the standard parameters of all the fetuses. We compared the acquired measurements with referent values, in order to establish that the fetuses showed normal growth and development.

The results of measurement of fetal development parameters are in agreement with the results of similar research conducted by Loughna et al., Otto and Platt, and Roelfsema et al., indicating normal growth and development.⁴⁻⁶

Our measurements of the mandibular length ranged from 1.9 cm to 3.1 cm, with an average of 2.3 cm, and these results are in accordance with the results of similar studies. Roelfsema et al. defined the average value of the mandible in the 18th gestational week as 1.3 cm and in the 34th week as 2.9 cm.⁶ Watson and Katz measured fetuses between 18 and 27 gestational weeks and concluded that the average anterior-posterior diameter of the mandible was 1,8 cm and 2.7 cm.⁷ The intrauterine growth of the mandible can be tracked using the ultrasound during the fetal life. It was Zalela et al. who established the mandibular ratio: Mandibular Ratio = $1,7759 (0,01047 \times \text{gestational week})$.⁸ The results of measuring the length of the mandible of our research

are in accordance with the results of the mentioned studies.

We compared this value to the habits of the mothers, the gender of the fetus, and any dental irregularities the parents might have and found no correlation (Table 2). Unfortunately, at present, there is no additional research about the effects of the habits of the mothers and the mandibular length.

We can confidently conclude that there is no difference in mandibular length between genders. Malas et al. examined 161 fetuses between the 9th and 40th gestational week. They found that the speed of mandibular growth was almost equal among all fetuses in the third trimester.⁹ According to Enlow, the speed of growth and remodeling in early childhood is also the same in both genders. The only differences between genders are in the contours of the inferior margin of the symphysis and the mandible itself in the prepubescent period.^{10,11}

The inferior facial angle was introduced by Rotten et al. as a parameter for establishing the position of the mandible in the sagittal plane. After examining fetuses between the 18th and 28th gestational week, they established an average value of 65.5° . Every value lower than 49.2° was defined as retrognathic.¹ We measured the average value of 53.3° .

This research did not show a correlation between the value of the inferior facial angle and the habits of the mother, dental irregularities, or the gender of the fetus (Table 3). According to Rotten, the value of the IFA increases with age because the chin grows anteriorly after birth.¹

Paladini et al. examined 262 normal fetuses in order to establish a jaw index: $\text{Jaw Index} = (\text{AP mandibular diameter} / \text{BPD}) * 100$.¹² Our measurements of the jaw index in this research were between 25.3 and 34.0, with an average of 26.0. We compared the value of the jaw index and the gender and found no differences (Table 4.). This is because, as Enlow indicated, differences become visible in the prepubescent age.¹⁰ We did, however, find a correlation between the use of progesterone in the mothers and the fetal jaw index. In fetuses where the pregnant woman consumed progesterone, the value of the jaw index was smaller. A correlation was also discovered between the use of tobacco and the value of the jaw index. Fetuses whose mother did not consume tobacco had a smaller lower facial angle than in cases where the mother did consume tobacco.¹³

A standard parameter that is frequently measured throughout pregnancy is fetal body mass. The body mass of fetuses in our research ranged from 1203 gr to 3701 gr (Table 5). When the body mass was compared to the habits of pregnant women and the fetal gender we found no correlation. However, a study from 2004 has shown that consuming tobacco during pregnancy is a health concern for both the mother and the fetus. The fetuses whose mothers consumed tobacco had a lower birth weight approximately by 200 gr.¹⁴

New studies show that not only does the mothers' consumption of tobacco affect the fetus, but also the father's smoking habits may have the same effect on the fetus in the same way.¹³ The

question, however, is, what constitutes an active smoker. Some studies show that up to five cigarettes a day do not affect fetal growth and development.¹³

In this research, we analyzed each profile pictures for parameters that indicate their overall development, development of the mandible, and the mandible position in the sagittal plane and also for scoring the fetal profile. A reliable method of analyzing fetal profiles is the use of photographs. During ultrasound examinations, a profile picture of the fetuses was captured. The tip of the upper lip, lower lip, subnasale and skin pogonion was compared to three vertical lines: Dreyfus, Simon and E-line. The tip of the upper lip in fetuses was shown to be anterior in relation to all three lines, while the tip of the lower lip was anterior only to the Dreyfus and Simon lines. Both the subnasale and the skin pogonion were anterior to the Simon line, but differed in relation to the Dreyfus line: Sn was anterior and the Pg' was posterior. The value of the facial angle immediately prior to birth is 155.2°. Schwartz uses a referent value of 168°±4° but in adults. The value of this angle depends on the Pg' position, which is why it is smaller in fetuses and babies:

The position of the Pg' changes with the growth of the chin, i.e., after birth. The results conclude that the fetal profile is distal. Trenouth showed that the speed of mandibular growth was different throughout fetal life and did not reach the speed of the development of the maxilla, which results in embryonal retrogenia.¹⁵ Bareggi identified mandibular progenia in younger fetuses and retrogenia in older fetuses.¹⁶

CONCLUSION

In the third trimester of intrauterine life, the average value of the mandible length is 2.3 cm. There is no difference in mandibular length between genders. The physiological position of the mandible is retrognathic and the value of the inferior facial angle was 53.3°. Average value of jaw index is 26, and there are no statistical differences between genders.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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