Alveolar ridge at 11-13 weeks screening - a 3D ultrasound study

Abstract

Objective. *The aim of the present study was to demonstrate and measure the normal alveolar ridge, on three-dimensional (3D) volumes obtained when performing the screening for the end of the Ist trimester.* ***Methods.*** *A group of 121 pregnant patients, each pregnancy with a single fetus. Each fetus had a 3D volume acquired between 11+0 and 13+6 weeks. The alveolar ridge area measurement was performed by two different operators.* ***Results.*** *From 120 volumes, at 100 fetus volumes, we obtained using multiplane processing, sections similar to the one from the miscarriage (82.64%). Measurement of alveolar ridge area was possible in cross section obtained in all 100 volumes, without any significant differences between the two operators (mean 0.1900 cm2, 95% CI: 0.1754-0.2046, 0.1908 versus mean, 95% CI= 0.1762-0.2054, p= 0.9389).* ***Conclusions.*** *Analysis of volumes, at the end of the Ist trimester ultrasound screening, obtains sections which contain and show the normal alveolar ridge, part of the palate.*

Keywords: *alveolar ridge, tridimensional ultrasound, screening, measurement*

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Acknowledgement: This paper is partially supported by the Sectorial Operational Programme Human Resources Development, financed from the European Social Fund and by the Romanian Government under the contract number POSDRU/89/1.5/S/64153 .

This paper is partially suported by internal research grants from the University of Medicine and Pharmacy Târgu-Mures, România, under the contract number 1093/1/30.01.2013.

Introduction

At the end of the fourth week of embryonic life, facial buds appear made from mesenchymal tissue derived from neural crest. Facial buds develop from the first pair of pharyngeal arches. Lateral from the stomodeum there are the maxillary buds and below this structure we find the mandible buds. In the next two weeks maxillary buds continue to grow in size. The space between the medial nasal buds and the maxillary ones disappear; by the fusion of two medial nasal buds and two maxillary buds the upper lip is formed[(1)]. The intermaxillary segment appears from the same four buds as the upper lip, having three components:

- labial - which forms the philtrum - the upper lips depression;
- maxillary bone - anterior part or premaxilla - with the superior four incisors;
- primary palate, triangulary shaped.

The secondary palate forms starting with the seventh week of embryonic life, from the paltine shelves. These are two flattened processes of the maxillary buds and fuse with each other and with the primary palate at the incisive suture. Between primary and secondary palate, on the middle line, there is incisive foramen. The secondary palate contains the hard palate, horizontal and the soft palate with the uvula. In females, the fusion of the palatine shelves takes place on week later than in males; this is why isolated cleft palate is more frequent on women[(1)].

In the sixth week of embryonic life, the basement membrane of the oral cavity epithelium forms the dental lamina at the maxilla and the mandible, from which the deciduous teeth buds are formed, 10 for each bone. Permanent teeth buds are formed in the third month of fetal development, on the medial side of deciduous teeth, they remain inactive until the age of 6[(1)].

Malformations, with frequency 1/1000 births in the cleft lip, up to 1/2500 births in isolated cleft palate, of the primary and secondary palate, include, depending on the affected area, cleft lip, gnathoschisis, cleft palate or combinations thereof. Anterolateral facial defect is due to lack of fusion between frontonasal and maxillary buds, unilateral or bilateral. It may limit to the lips or it may include the premaxilla. Posterior defect is due to lack of fusion of the two palatine shelves, among themselves or with the vomer. May be paramedian unilateral or bilateral; may extend to the soft palate[(2)].

Protrusion of a portion or of the entire region of anterior maxilla, lack of continuity of maxillary dental alveolar arch draws attention to possible orofacial abnormalities in fetal ultrasound.

Embryological and anatomical data indicate the importance of highlighting using ultrasound, the dental maxillary alveolar ridge, in fetuses in late first trimester. If the integrity of the alveolar ridge is present, then the structure of the primary palate with the anterior side of the maxilla and the four upper incisors will be normal. Cleft lip and cleft palate are distinct embryological malformations that originate in different moments of the embryological development having a multifactorial origin[(3)]. The alveolar ridge anomalies detected by ultrasound, have been associated with defects of closure of the palate by Goldstein and colleagues[(4)].

Methods

A group of 121 pregnant women with single pregnancy and normal fetal ultrasound which presented at the 11 weeks + 0 days - 13 weeks + 6 days screening, were examined with an ultrasound scanner which is equipped with a 3D abdominal and vaginal transducer with the acquisition of a volume that included fetal head, with

Received: *January 27, 2013*
Revised: *February 15, 2013*
Accepted: *April 02, 2013*

the ultrasound beam directly to the fetus face, with an angle between the transducer and the long axis of nose as nearly as 45 degrees. For every fetus who has not met the requirements for the volume acquisition having a 'free' face, the patient was called back a few hours or a few days later. Each patient had been counseled and had an informed consent. The volume acquisition was performed by the same operator (CM). Practically, each fetus had a volume acquired at the described gestational age, in the period 01.01.2011 - 31.03.2012. The ultrasound machine used was an Acuson S2000, Siemens, with 7CF2 abdominal transducer and a 9EVF4 vaginal transducer (Siemens Healthcare - Manufacturers' name: Siemens, Model Acuson S 2000, Florida, United States, in 2010).

Fetuses which were not considered to be in a good position to have the volume acquisition with the abdominal probe, were examined with the vaginal probe (16 volumes were acquired). The acquisition was made with the 55 degrees angle and maximum possible quality. Further analysis, in the ultrasound machine database, of the acquired volume, using multi plane and multi slice technique, until we obtained an axial (transverse) section which includes the hard palate, made possible the highlight of the alveolar ridge, a hyperechoic bowshaped area, situated at the anterior part of the palate and measuring its area (Figure 1).

Processing volumes and biparietal diameter measurement was made individually by another operator (COM). At multi plane processing, plane A was a sagittal section - the fetal profile with the hyperechoic part of the palate being horizontally; B coronal plane of the face with the retronasal triangle described by Sepulveda and plane C - axial section, with the hyperechoic bowshaped area placed anterior - the maxillary alveolar ridge (Figure 2).

The landmark, at the intersection of the three planes, was situated on plane A, just anterior of the palate. When processing the 121 volumes, in 21 cases, the obtained axial sections were not considered 'clear' and it couldn't be obtained the bowshaped hyperechoic image of the anterior part of the maxilla. Processing was performed with high dynamic TCE, tint 14 and contrast scale E. The 100 volumes, in which the axial sections had obvious fetal maxillas were analyzed by two different operators (CM - measurements of column A, COM - measurements of column B) with the measurement of the alveolar ridge area. Comparing the results of the two series of 100 areas, was performed to highlight any differences. In parallel, three fetuses spontaneously aborted at 11, 12 and 13 weeks were studied after cross section of the head in the plane of the mouth, with highlighting the hard palate and maxillary alveolar ridge in order to compare images obtained using ultrasound with the ones from the anatomical sections (Figure 3).

Data were processed in Excel and statistical analysis was done using Graph Pad Prism software. For variables it was calculated the mean ± standard deviation. For comparison of measurements, T student test was used.

Informed consent was obtained from parents or legal tutors in compliance with the principles of the Helsinki Declaration, at the moment of admission to the hospital. The study was approved by the local Committee of Ethics of the University of Medicine and Pharmacy Târgu-Mureş from Romania.

Results

From 120 volumes, 100 fetal volumes led, by multi plane processing, to obtain sections similar with the images from the anatomical sections (82.64%). The hyperechoic bowshaped area, from the anterior part of the maxilla, which represents the alveolar ridge, was highlighted in each of these 100 3D volumes. The

Figure 1. A 12 weeks fetus, cross section of the head

Figure 2. Maxillary alveolar ridge in yellowin a 3D ultrasound

Figure 3. Upper right - coronal section with the retronasal triangle described by Sepulveda[17]

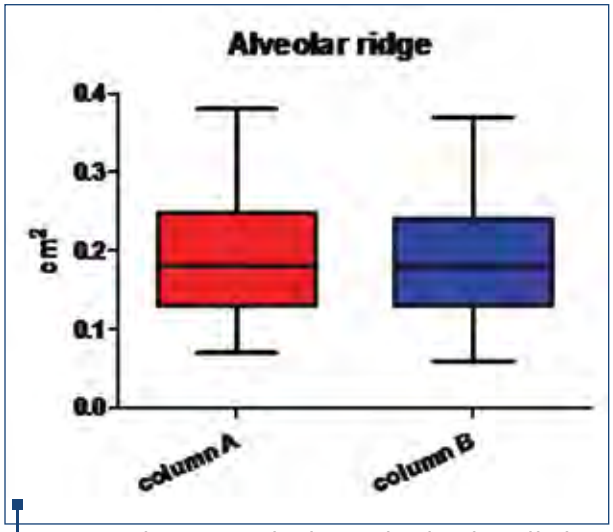

Figure 4. Box plot comparison chart between the values obtained by the two operators when measuring the alveolar ridge

measure of the alveolar arch area was possible in each cross section of the 100 volumes acquired.

The minimum, maximum, median and standard deviations were calculated for biparietal diameter (BPD), days of amenorrhea and maxillary dental alveolar ridge area (alveolar ridge). Calculations were performed for both operators, which evaluated the alveolar ridge area (Tables 1 and 2).

When the difference between the mean of the two measurements of alveolar ridge area was compared using T student test, it didn't show a statistically significant difference between columns A from table 1 and column B from table II, 'p' value is 0.93 (Table 3).

The mean of the areas in square centimeters of column A of table I, is 0.1900 and the mean from column B of table II is 0.1908, so the difference between the means is 0.0008 square centimetres (Table 4).

A comparison chart between the values obtained by the two operators when measuring the alveolar ridge its in Figure 4.

Discussion

In the presence of maxillary dental alveolar ridge integrity, primary palate with the anterior side of the maxilla and the four upper incisors will have a normal structure. Theoretically, three-dimensional ultrasound may indicate the anatomical structure of the primary palate since the end of embryological development, from 10 to 11 gestational weeks.

Concerns for ultrasound diagnosis of fetal palate defects have existed since the mid-80s[5] and early '90s[6] with practical importance because of possible associations of chromosomal abnormalities[7]. Goldstein and colleagues[4] and Sherer et al.[8] described even a diagram of the fetal palate. These authors used conventional two-dimensional ultrasound. Goldstein and colleagues[9] put together a diagram of the fetal profile using 3D ultrasound. Rotten and colleagues[2] showed, in their study on fetuses with orofacial defects, that the best way to evaluate dental alveoli and the maxilla is in axial plane (transverse) of the multi plane ultrasound and the secondary palate - in coronal plane. The method of exploring the alveoli and the maxilla using multi plane 3D ultrasound has been described by other authors[2,10-14] Johnson and colleagues[15] compared the two-dimensional ultrasound with the three-dimensional ultrasound in a study of the fetal face, upper lip and primary palate defects, suggesting the superiority of 3D ultrasound. Campbell[16] found that the acoustic shadow, caused by the maxilla when performing a facial scan from the anterior towards the posterior, reduces the quality of the palate. Thus Campbell described the technique, 'reverse-face view', in which the face coronal plane is reversed 180 degrees and the scan is performed from posterior to anterior. Campbell and contributors[16] described as well a combined 3D rendering ultrasound technique in order to highlight the maxilla and the palate – 'tilt and scroll method'[17]. As an application of this technique, Sommerlad and collaborators[18] describe the ultrasound diagnosis of malformations of fetal upper lip and maxilla. Pilu and colleagues[19] proposed the volume acquisition at an angle of 45 degrees to the palate, under the chin, then processed the sections using the tomography method to highlight the palate. Two studies[20,21] described the technique of highlighting the retronasal triangle at 11 to 13 gestational weeks in the coronal plane of the fetal face, consisting of three hyperechoic lines: two of them being the frontal processes of the maxilla and the horizontally line - the primary palate. Goldstein and colleagues[4] describe a nomogram of fetal maxillary alveolar ridge between 14 and 32 weeks. Neither the study

Table 1 Results of the measurements of operator C M[1]

	BPD(mm)	Days of amenorrhea	Alveolar ridge area (cm^2) - Column A
Number of values	100	100	100
Minimum	13,20	77,00	0,0700
25% Percentile	19,90	84,25	0,1300
Median	21,40	89,00	0,1800
75% Percentile	23,28	92,00	0,2475
Maximum	28,00	98,00	0,3800
Mean	21,39	88,34	0,1900
Std. Deviation	3,084	5,446	0,07379
Lower 95% CI of mean	20,78	87,26	0,1754
Upper 95% CI of mean	22,00	89,42	0,2046

Table 2 Results of the measurements of operator COM[2]

	BPD (mm)	Days of amenorrhea	Alveolar ridge area (cm^2) Column B
Number of values	100	100	100
Minimum	13,20	77,00	0,0600
25% Percentile	19,90	84,25	0,1300
Median	21,40	89,00	0,1800
75% Percentile	23,28	92,00	0,2400
Maximum	28,00	98,00	0,3700
Mean	21,39	88,34	0,1908
Std. Deviation	3,084	5,446	0,07370
Lower 95% CI of mean	20,78	87,26	0,1762
Upper 95% CI of mean	22,00	89,42	0,2054

Table 3 P value, mean and the differences between calculated area

P value	**0,9389**
P value summary	ns
Are means significant different? (p <0.05)	No
How big is the difference?	
Mean ± SEM of column A	0,1900 ± 0,007379 N=100
Mean ± SEM of column B	0,1908 ± 0,007370 N=100
Difference between means	-0,0008000 ± 0,01043

Table 4 Alveolar ridge mean, standard deviation and confidence interval for the two measurements

	Alveolar ridge area (cm^2)	Column A	Column B
Number of values		100	100
Minimum		0,0700	0,0600
25% Percentile		0,1300	0,1300
Median		0,1800	0,1800
75% Percentile		0,2475	0,2400
Maximum		0,3800	0,3700
Mean		0,1900	0,1908
Std. Deviation		0,07379	0,07370
Lower 95% CI		0,1754	0,1762
Upper 95% CI		0,2046	0,2054

by Sherer et al.[8] has fetuses under age of 14 weeks. This study practically aims the possibility to highlight, on 3D volume stored at the screening of the end of first-trimester, the maxillary dental alveolar ridge that is part of the intact primary palate. The results are encouraging, for the evaluation of the primary palate, on 3D stored volumes, from the age when the first fetal screening is done.

Conclusions

Maxillary dental alveolar ridge can be evaluated in fetuses using three-dimensional multi plane ultrasound with implications in the exclusion of orofacial abnormalities, the images obtained being similar to those of anatomical preparations. A 3D volumes, stored when doing the fetal screening at the end of first trimester, can be used in large proportion, over 82% to detect the integrity of maxillary alveolar ridge, part of the primary palate. Measuring the maxillary dental alveolar ridge, is reliable, on processed section from stored 3D volumes, and is a possible evaluation of the intact primary palate, from 11 to 14 weeks. ■

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