

# The Study of the Maxillary Growth and Primary Fetal Palate Through Multiplanary Three-Dimensional Ultrasound – Skeletal Rendering

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**Introduction:** This study aims to suggest a new technique for the ultrasound assessment of fetal facial bones at the end of the first trimester and the beginning of the second gestational trimester.

**Material and method:** The study was conducted over a period of 6 months, between October 2010 and March 2011, on a number of 52 acquired fetal 3D volumes, stocked by the same operator, on fetuses with normal echo structure, from unique pregnancies. The cohort of 52 fetuses had the gestational age between 12–14 weeks. Ultrasonographies were made at 16–17 weeks and 22–24 weeks. The methodology for the evidence of primary palate and maxillary alveolar used a 3D multiplanary ultrasonography technique “Face Reverse View” with Maxi IP and Skeletal Rendering.

**Results:** Practically, in all volumes the presence of the jaw with alveolar ridge and primary palate as single, uninterrupted structure has been documented.

**Conclusions:** The usage of Skeletal Rendering can provide further information at the level of the cranial bone, especially in the first half of pregnancy.

**Keywords:** maxillary growth, primary palate, 3D ultrasound, skeletal rendering

## Introduction

Since the introduction of three-dimensional ultrasonography, several sites and software techniques have been used to study fetal jaws and mandible. Originally Maxi-IP was used for the study of bones, then new applications have improved the image quality. This study aims to propose a new technique for the ultrasound assessment of fetal facial bones at the end of the first trimester and the beginning of the second gestational trimester. The intermaxillary segment is formed from the same four shoots – two medial nasal shoots and two maxillary shoots, as the upper lip has three components:

- ▶ Labial which forms the filtrum – upper lip depression;
- ▶ Maxillary bone – previous and pre-maxillary – with the four upper incises;
- ▶ Primary palate, with a triangular shape.

The secondary palate is formed starting from the seventh embryonic week, from palatal plate. These are two flattened processes of the maxillary buds, both among themselves and with the primary palate at the level of the incisivo-palatine suture.

Embryological data indicate the start of jaw formation, primary and secondary palate since the seventh week of embryonic life [1]. At 11–12 gestational weeks the punctiform hyper-ecogenity of the jaw is clearly visible in ultrasonography which has a good 2 D resolution.

## Material and method

The study was carried out over a period of 6 months, between October 2010 and March 2011, on a number of 52 acquired fetal 3D volumes, taken by the same operator,

on fetuses with normal echo structure, from unique pregnancies. The device used was an Siemens Acuson S 2000, with a 7CF2 abdominal transducer and a 9EVF4 vaginal transducer. The pregnant women were scanned with an acquired volume which included the fetal head, with ultrasound beam direction directly to the fetus’ face, with an angle between the transducer and the long axis of the nose as close to 45 degrees. The essential condition for the acquisition of the volume was that the fetal face was free, without fetal structures like limbs or umbilicum nearby, or structures like womb or joined placenta.

The quality of the acquired 3D volume was checked by getting a “Surface Rendering” image with free fetal face, with clear outline. The patients in which the position or the fetal movements could not obtain the best volume,

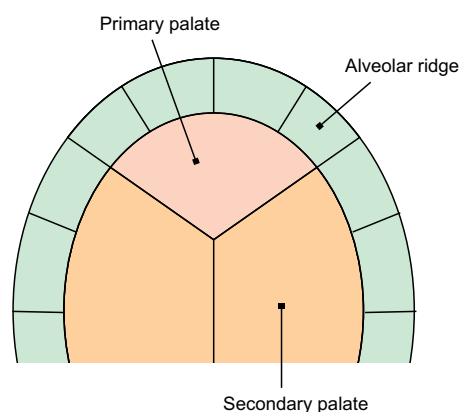


Fig. 1. Simplified diagram of the primary and secondary palate, surrounded by alveolar ridge (author's drawing).

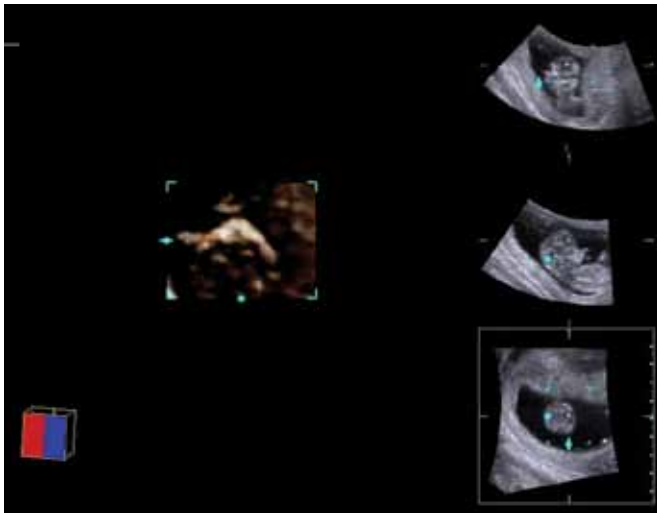


Fig. 2. Multiplanary ultrasonography with an A quadrant, right part, middle with sagittal section of the fetal skull extremity, the quadrant B right part top with coronal section, quadrant C bottom right with axial section. To the left – the volume with “bottom view” of the jaw and primary palate with Skeletal Rendering software, the quadrilateral dotted with green represents this volume in the 3 quadrants A, B, C. Gestational age: 12 weeks.

were recalled after several hours or days for a new fetal face ultrasound. At the initial 12–14 weeks ultrasonography, 42 volumes were acquired abdominally and 12 vaginally. The cohort of 52 fetuses had the initial gestational age between 12–14 weeks, then the ultrasonographies were carried out at 16–17 weeks and 22–24 weeks. Each fetus had 3 ultrasonographies with acquired volume at the ages described by pregnancy. The volume processing was initially carried out through multiplanary technique, as follows:

- ▶ in the A quadrant the sagittal section of the fetal skull
- ▶ in the B quadrant the coronal section

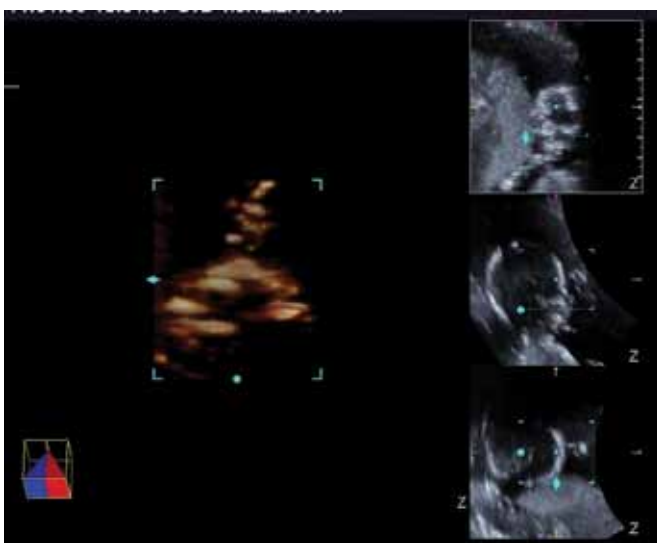


Fig. 4. A 16-week fetus. Multiplanary ultrasonography, with A quadrants, from the right part, middle, with the extremity sagittal section of fetal skull, B quadrants, top right part with the coronal section, C bottom right part with axial section. In the left part – the volume with “bottom view” of the jaw and primary palate with a Skeletal Rendering soft, the quadrangle dotted with green representing the volume in the three quadrants A, B, C

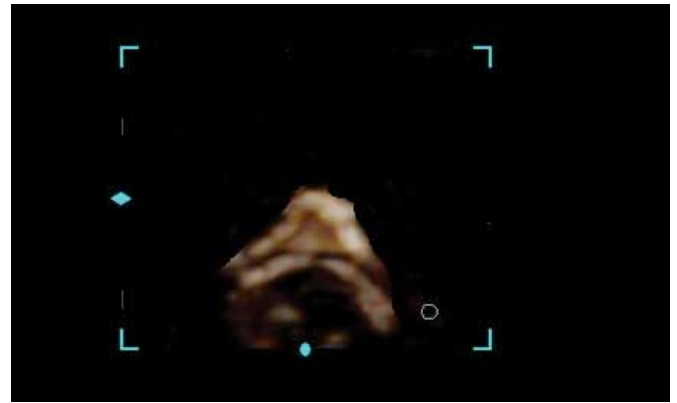


Fig. 3. Skeletal Rendering in the fetus with the face up and section from the mouth to the previous figure, on the option with a single quadrant displayed on a monitor – the jaw can be seen in a “V” shape, rounded and open bottom, under it being the trapezoidal primary palate. The semicircle open bottom, beneath the palate, represents the frontal bones.

- ▶ in the C section the axial and transversal section
- ▶ the landmark – the intersection of the three orthogonal plans – was found at the hyperechogenic line of the jaw and in front of it.

After the image was processed in a multiplanary way, so that the jaw with alveolar ridge and primary palate on the axial section were clearly visible, the volume of interest focused on the described bone segment “bottom view”. Practically, a volume of the viscerocranium bones resulted seen from the mouth, towards the palate and jaw, on the axial plan. On this volume the image was processed with “Skeletal Rendering” software, which highlights the bones from this level. For the simultaneous image of the coronal section, a 180 degrees plan was processed, obtaining the echostructure described by Campbell as “Reverse Face View”, where first Maxi IP software was used followed by Skeletal Rendering.

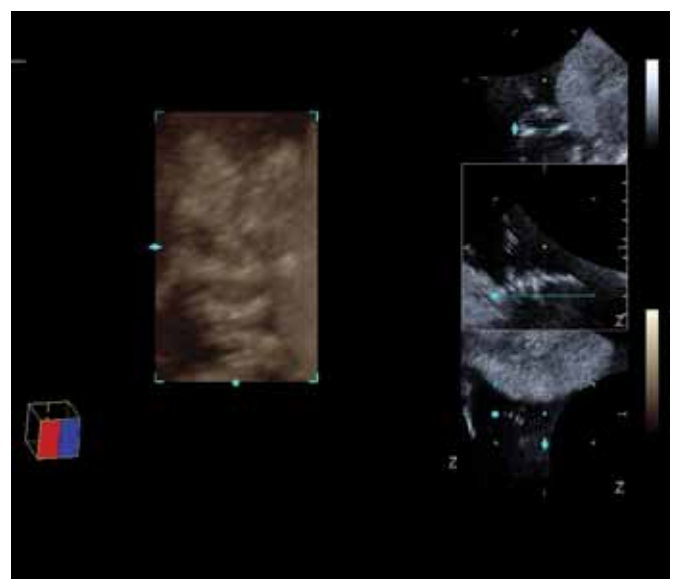


Fig. 5. Reverse face view, with the Maxi IP software in a 16-week fetus

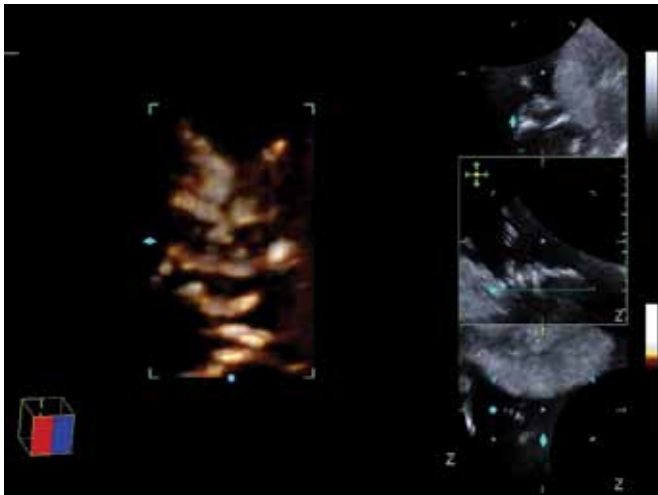


Fig. 6. Reverse face view, with Skeletal rendering in the same 16-week fetus

The methodology for the evidence of primary palate and maxillary alveolar used: 3-D multiplanary ultrasonography, the technique “Face Reverse IP Maxi View” with Skeletal Rendering.

## Results

A total number of 156 volumes were processed, according to the succession of 3 ultrasonographies in each of the 52 fetuses. The initial processing through multiplanary technique highlighted the three main plans of section. On the reduced volume, the Skeletal Rendering application led to a smooth highlighting of the jaw and primary palate in a different proportion, depending on the gestational age:

- ▶ 48 of 52 volumes at 12–14 weeks;
- ▶ 44 of 52 volumes at 16–17 weeks;
- ▶ 38 of 52 volumes at 22–24 weeks.

Using the Maxi IP application in a coronal plan, with the technique “Reverse Face View” and especially Skeletal Rendering, highlighted the jaw in the other volumes, where the axial plan and the limited volume only in the jaw and palate “bottom view” were useless.

In all volumes, after processing, the presence of the jaw with alveolar ridge and primary palate with unique, uninterrupted structure were noted.

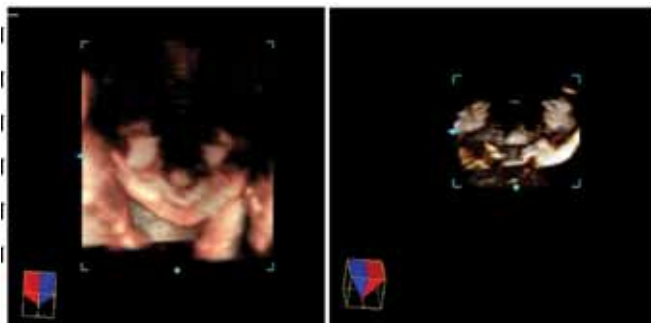


Fig. 8. The fetal jaw at 24 weeks “tilt and scroll method” – left side with Amnioscopic Rendering, right side with Skeletal Rendering

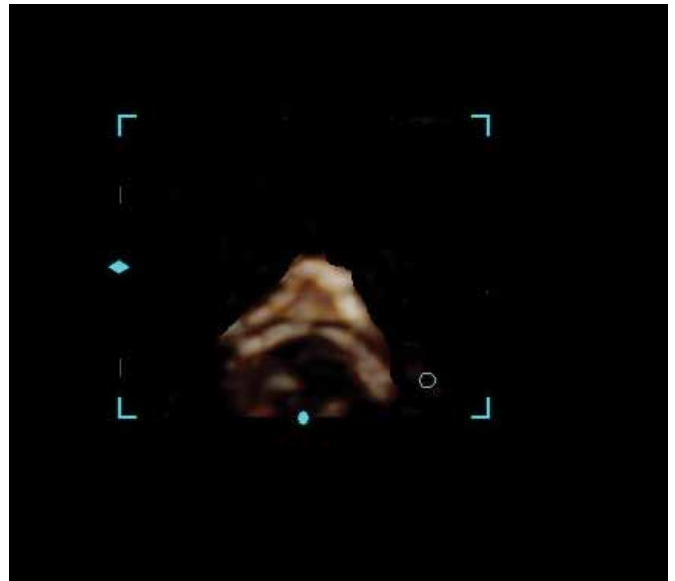


Fig. 7. A 24-week fetus with the initial acquired volume for the “top view” of the jaw and the palate through the “tilt and scroll method” described by Campbell

## Discussions

Concerns for ultrasound diagnosis of fetal palate defects have existed since the mid-80s Pilu et al. [2] and the beginning of the 90s Benacerraf et al [3]. Sherer et al. also described a nomogram of the fetal palate [4]. Rotten et al [5] showed in their study on fetuses with orofacial defects that the dental alveoli and the jaw can be best assessed in the axial plan of the multiplanary ultrasonography, while the secondary palate in the coronal plan. The method of exploration of the alveoli and jaw through 3D multiplanary ultrasonography was described by other authors

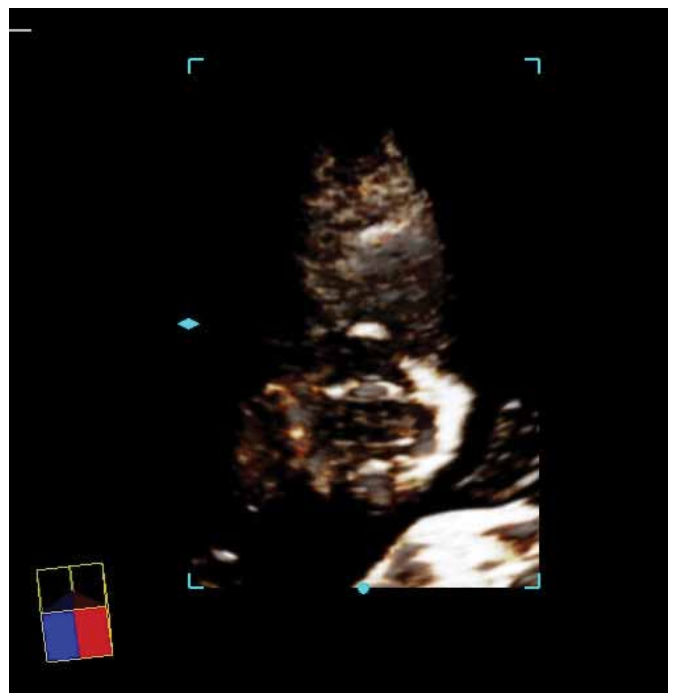


Fig. 9. Reverse face view in the same fetus of 24 weeks, with Skeletal Rendering

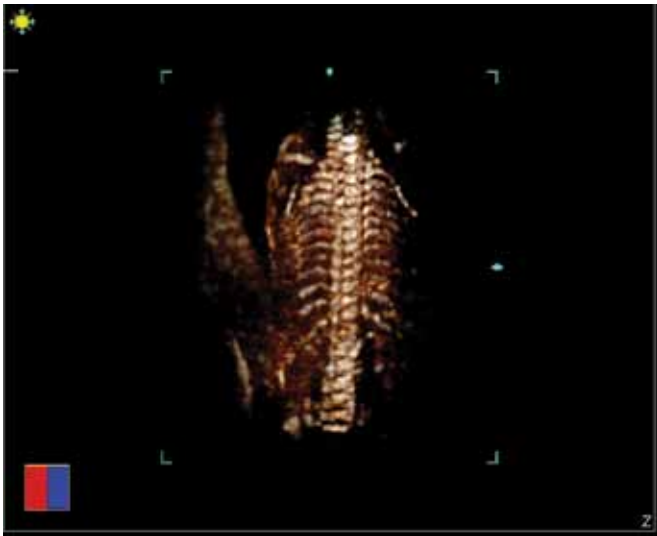


Fig. 2. Skeletal Rendering with bone structure reconstruction of the thorax and spine, in a normal fetus of 22 weeks. Here the application was used in order to be recommended by the manufacturer.

too [6,7,8,9,10,11]. Campbell et al [12] noticed that the acoustic shadow determined by the jaw when the face was scanned from anterior to posterior decreased the quality of the palate image. Thus, Campbell described the technique reverse-“face view”, where the coronal plan of the face rotates with 180 degrees and is scanned from posterior to anterior. Campbell [13] also described a combined technique of 3D Rendering ultrasonography in order to evidence the jaw and palate – “tilt and scroll method”. Benacerraf et al [14] described a defect of soft palate in the axial plan of the three dimensional ultrasonography, supplementarily highlighted through nuclear resonance. Platt et al [15] described another technique in order to obtain 3D rendering axial sections for the soft and harsh palate – the “flipped-face view”. Pilu et al [16] suggest the volume acquisition under an angle of 45° beside the palate, then its processing of the sections through the method of the homographic sections. Sepulveda et al [17] described the technique of retro nasal triangle, at 11–13 gestational age, in the coronal plan of the fetal face, formed by three hyper ecogenius lines: two of them being frontal processes of the maxilla and the horizontal line of the primary palate.

“Skeletal rendering” is a software dedicated to the study of the fetal spine, of the fetal thorax, in use since 2009 by the producer. Its applications are very helpful in case of suspected skeletal dysplasia.

Using the Skeletal Rendering application increases the contrast between the fetal bone parts and the soft tissues with a better highlight of the aimed structure. The images obtained with the help of this software at the level of the fetal skull are good at the end of the first trimester and the beginning of the second one, when the ossification is barely at the beginning, at structures of reduced size. The advantages of this software for highlighting the primary palate and jaw with alveolar ridge, in the axial plan or transversal plan of the fetal skull:

- images with good contrast between the bone structure and the rest of the tissues or amniotic liquid;
- the high mechanization-practically after choosing the aimed volume, a single touch of the button apply Skeletal Rendering to the structures
- superior images for the bone structure compared to those obtained through Maxi IP application

The disadvantages are:

- “the window” is relatively narrow, the gestational age when the best images are obtained is approximately between 12–18 weeks;
- it needs multiplanary 3D processing and the volume reduction on the aimed structures.

The disadvantages can be compensated by using “Reverse Face View” and then applying Skeletal Rendering, obtaining a coronal plan with fetal jaw.

## Conclusions

Using Skeletal Rendering can provide us with further information at the level of the skull bones, especially in the first half of pregnancy. This study was conducted only on fetuses with normal echo structures, further researches on orofacial anomalies will have to assess the value of the method, associating the multiplanary 3D ultrasonography, the technique “Reverse Face View” with Maxi IP and Skeletal Rendering.

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