Nasal bone assessment by 3D versus 2D ultrasound in the 11-13 gestational weeks screening

Abstract

Objective. *The aim of our study was to assess the usefulness of a single three-dimensional (3D) volume acquisition for the study and measurement of fetal nasal-bone at 11-13 week's gestation.* ***Methods.*** *A group of 121 pregnant women with singleton pregnancy and normal 2D fetal ecostructure, were analyzed in terms of a volume of fetal skull. The correlation between nasal bone length measured in 2D and 3D ultrasound by 2 different operators was determined. We used Med Calc and Graphpad Prisma statistical software.* ***Results.*** *From the total fetuses with nasal bone presented in 2D ultrasound, only in these 101 3D volumes the nasal bone was clearly revealed, multiplanar processing resulted in fetal nasal bone measurement. There were no differences between 3D ultrasound measurement of nasal bone nor between 2D versus 3D ultrasound measurement.* ***Conclusions.*** *Further processing of volumes with multiplanar sections that can be replicated and standardized in fetal screening of the end of the first quarter has similar results to 2D ultrasound measurement of the nasal bone.*

Keywords: *nasal-bone, screening, ultrasound, multiplanar sections*

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Introduction

In recent years, three dimensional (3D) ultrasound studies were used in the study of the fetal face. The possibility of acquisition of a volume that includes all fetal cephalic extremity, with further processing in different sections of the nasal bone imaging has opened new perspectives on the study of an ultrasound sign that can be an indicator of genetic syndromes.

Fetal sonography performed as screening between 11 and 13 weeks and 6 days has gained importance in pregnancy follow-up. Ultrasound studies were described in 11 to 14 gestational weeks in the absence of nasal bone in about 65% of fetuses with Down syndrome, in respect to 1-3% nasal bone absence in fetuses with normal karyotype[5,6]. Sonek and collaborators[20] examined 15,460 fetuses with ultrasound screening of 1st term, indicates the absence of nasal bone in 68.4% of the fetuses with Down syndrome, versus only 1.2% in fetuses with normal karyotype.

As the fetus grows, absence of the nasal bone in the 2nd term of pregnancy was reported in 30% of the cases and hypoplasia in 30% Down syndrome cases[21]. Study of the nasal bone is a long-time process, which required operator-dependent in 2D ultrasound, due to difficult to obtain perfect sagittal section. Another issue that impacts the 2D ultrasound image is the anatomical presence of two nasal bones, each with a minimum deviation towards the nose tip, versus normal sagittal section of the nasal base.

The aim of our study was to asses and measures the nasal bone with 3D versus measurement in 2D in stored volumes and captures, using both interobservational and intraobservational agreement.

Methods

A group of 121 pregnant women with singleton pregnancy and normal 2D fetal eco-structure, presenting nasal bone in 2D ultrasound, screened at 11+ 0-13+ 6 gestational weeks were scanned for 3D abdominal and vaginal transducer. The volume acquiring included the fetal head, with the ultrasound beam directly to the fetus face, and an angle between the transducer and the long axis of the nose as close to 45°. The fetal head occupied almost the entire "box" of the acquired volume by 55°, with maximum quality for 1s. Informed consent was obtained from each pregnant women before taking part in the survey. Further analysis of the volume through multislice technique to obtain a sagittal brain section conducted to evidence and measurement of the nasal bone in sagittal section. Processing was performed with high dynamic TEC 14 and contrast E scales.

In parallel, 2D morphological fetal ultrasound was performed for every pregnant woman, recording a sagittal section of the fetal skull used for measurement of the nuchal translucency and the nasal bone, as described by Cicero et al. and Plasencia and co-workers[5,14]. We employed a Siemens Acuson S 2000, with 7CF2 abdominal and 9EVF4 vaginal transducer. Fetuses that were not considered to be in an ideal position for volume acquisition by abdominal sample were examined only by vaginal ultrasound probe. Thus 103 volumes were acquired by abdominal and 18 by vaginal ultrasound. At the beginning of the investigation it was essential that the fetus face should have no umbilical cord or limb in the neighborhood (i.e. 'free face'), and the fetus to be immobile. The volume was subsequently processed in multiplanar and multislice mode so as the sagittal head section, the coronal plane of the face and a

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cross section along both nasal bones, with the region of future orbits nearby should be included. Each plane of the section included the whole fetal cephalic extremity. The images obtained were considered useful if:

i) both nasal bones were clearly distinguished, symmetric, near the orbits cross-sectional or axial plane (plane C);

ii) the coronal plane was symmetrical, derived from the coronal plane with Sepulveda retronasal triangle[19] (plane B);

iii) the sagittal plane was ideal, as described by Plasencia and collaborators with the presence of echogenic nose and rectangular palate[14]. Absence of nasal tip or presence of frontal process of maxilla shows a parasagittal or oblique rotation section, which does not allow correct measurement of the nasal bone (plane A).

Volume acquisition storage of 2D and 3D images was performed by a single operator. Processing of 3D volumes with nasal bone measurement in sagittal section and 2D stored images in each fetus was performed by two independent operators. According to normal settings of the machine, each track-ball movement was equivalent to 0.1 mm. The correlation between nasal bone length measured by 2D and 3D ultrasound by each of the two operators, and any differences between them were statistically analyzed.

As statistical software we used Med Calc and Graphpad Prisma. To illustrate the variability of measurements from and/or between the two operators (interobservational and intraobservational) student t test, Pearson correlation coefficient, and Bland and Altman method[2] were applied.

Results

After processing the 121 volumes, both operators confirmed they obtained 'ideal' 3D sagittal section only in 102 cases. Of these, only 101 were identical in both operators (82.78% of total acquired volumes). From the 121 fetuses with nasal bone presented in 2D ultrasound, only in these 101 3D volumes the nasal bone was clearly revealed. Volumes considered without 'clear' sections were caused by fetal movements at the time of acquisition.

No statistically significant differences were found between 2D and 3D means for the 1st operator on application of student t test between 2 D and 3D measurements.

Moreover, Bland and Altman diagram (Figure 1) showed the limits of the 95% ranges of the 1st operator which varies between +0.14 and -0.14 mm. This means that 95% of variation considered 'normal' is found between these limits.

Using the student t test for the 2nd operator on the means of 2D and 3D measurements, the result was statistically insignificant. Bland and Altman diagram showed in Figure 2 the limits of 95% of agreed intervals for the 2nd operator, which is between 0.47 and -0.46 mm, showing that 95% of variations considered 'normal' are found between these limits and also there are higher than to the 1st operator. The intraobserver variability of the 2nd operator between nasal bone 2D and 3D measurements varies in range of ± 0.4 mm.

Statistical comparison between nasal bone measurements in the two operators

We applied the student t test on the 2D and 3D measurement of the 1st operator and 2D measurement of the 2nd operator, which showed us insignificant results (Table 1).

The limits of 95% of interobserver agreement for 2D measurements varies between 0.29 and -0.28 mm. Interestingly, the interobserver agreement of nasal bone measurements in 2D was found in range of ±0.3 mm (see Figure 3).

For the 3D measurements, the 95% limits for the interobserver agreement expressed as Bland and

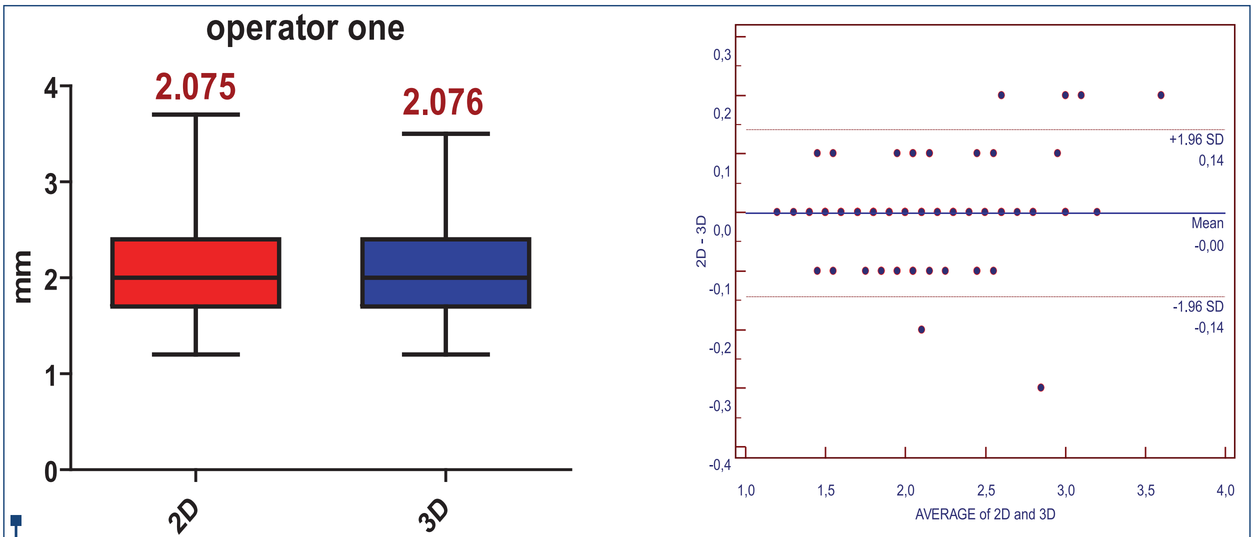

Figure 1. Blox plot chart indicates lack of statistically significant difference between nasal bone measurements respectively the Bland-Altman analysis used to compare the consistency and bias between 2D and 3D measurements by the 1st operator

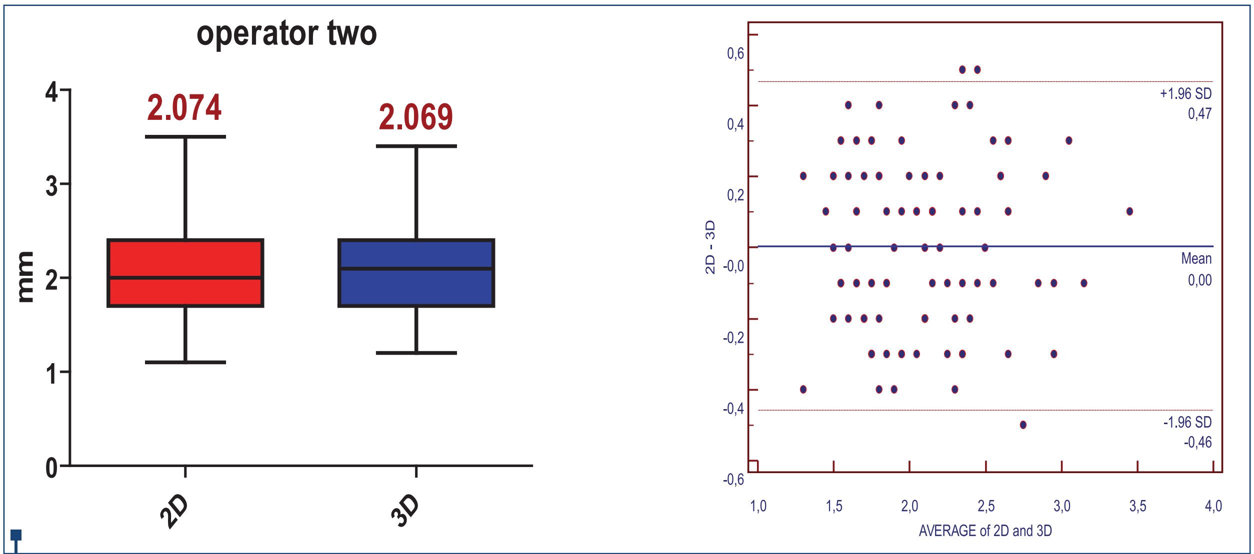

Figure 2. Blox plot chart showing statistically significant difference between nasal bone measurements and the Bland-Altman analysis in respect to the consistency and bias between 2D and 3D measurements

Table 1 Differences between nasal bone measurement by 2D and 3D ultrasound in both operators (101 cases total)

	2D ultrasound		3D ultrasound	
	1st Operator	2nd Operator	1st Operator	2nd Operator
Minimum (mm)	1.2	1.1	1.2	1.2
Maximum (mm)	3.7	3.5	3.5	3.4
Mean	2.075	2.074	2.076	2.069
Std. Deviation	0.4928	0.4673	0.4786	0.4580

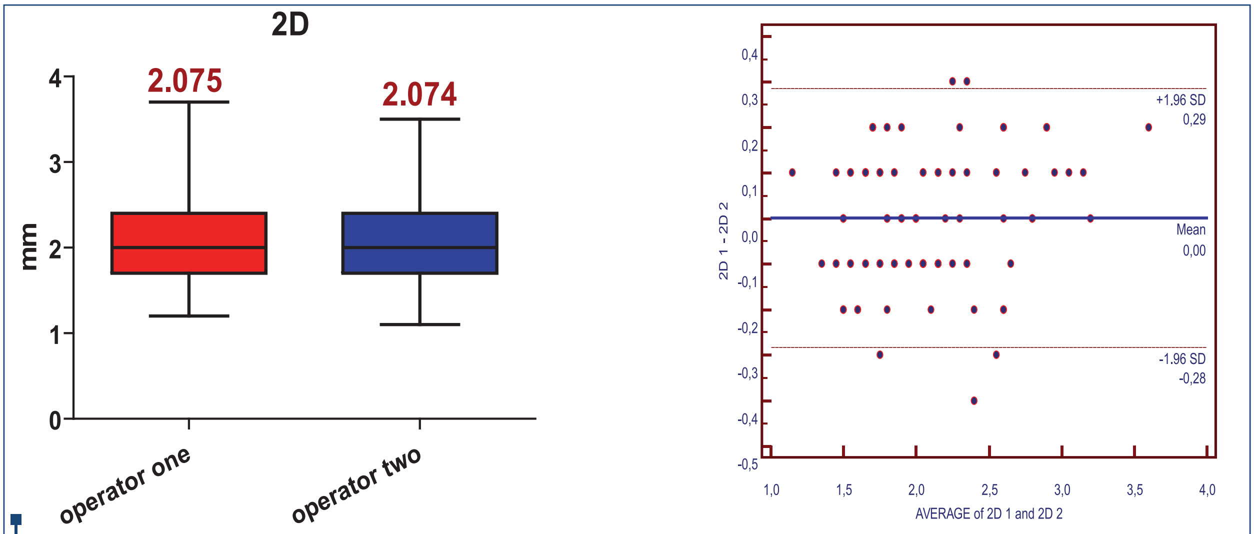

Figure 3. Blox plot chart showing no statistically significant difference between nasal bone measurements in the two operators by 2D ultrasound and the Bland-Altman analysis in respect to the consistency and the bias between the performed measurements

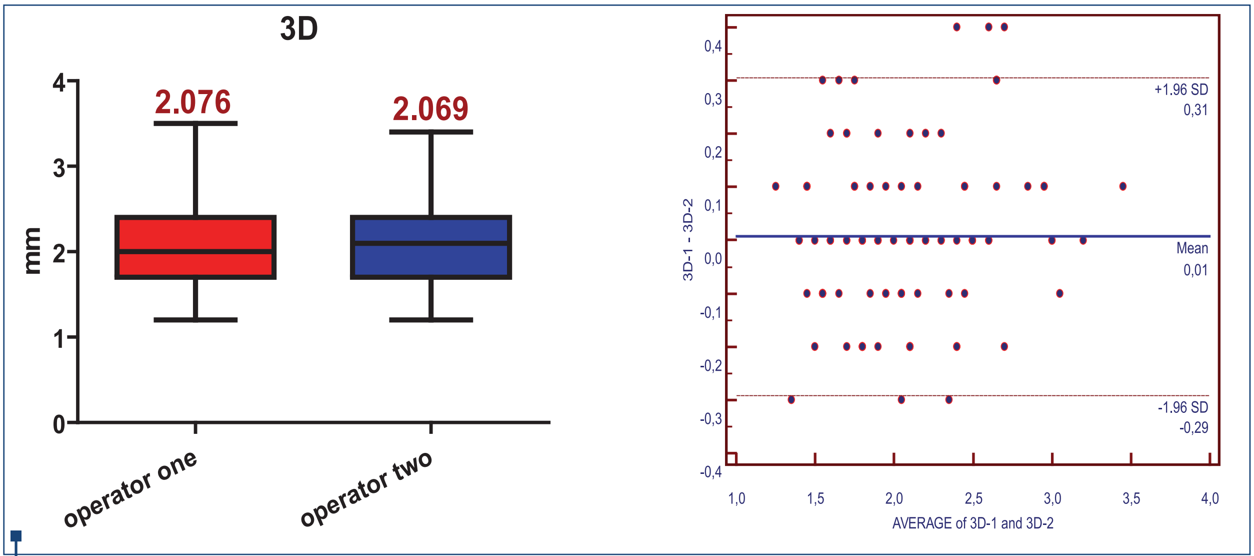

Figure 4. Blox plot chart showing no statistically significant difference between nasal bone measurements in the two operators by 3D ultrasound and the Bland-Altman analysis in respect to the consistency and the bias between the performed measurements

Altman diagram, are between 0.31 and -0.29 mm, slightly higher than in the 2D measurements (see Figure 4).

The corresponding values for intraobserver agreement between 2D measurements versus 3D, were ± 6,2% for the 1st operator and ± 23,5% for the 2nd operator (Figures 5, 6, 7 and 8).

The corresponding values for interobserver agreement were ± 14,2% for 2D measurements, and ± 15,1% for 3D measurements (Figures 9 and 10).

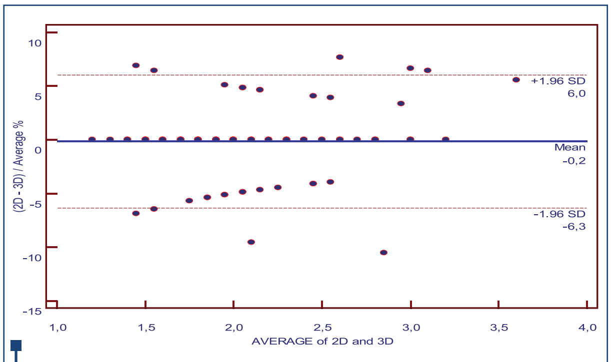

Figure 5. The corresponding values for intraobserver differences for 1st operator

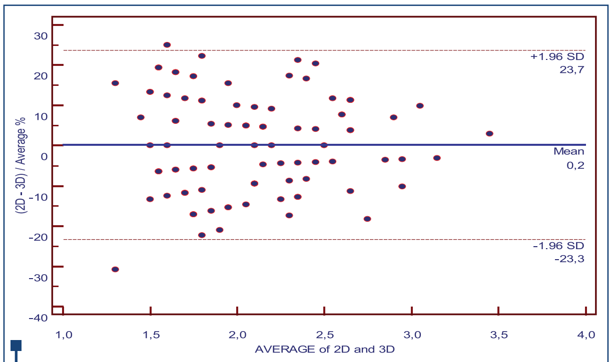

Figure 6. The corresponding values for intraobserver differences for 2nd operator

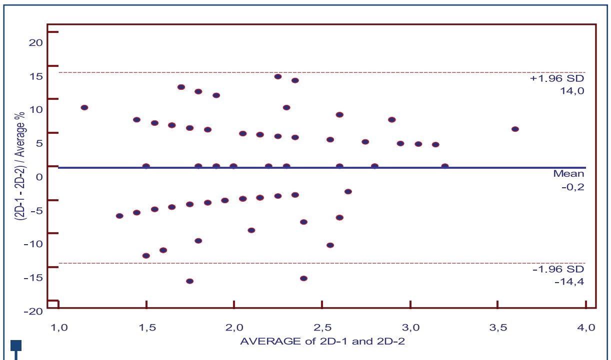

Figure 7. The corresponding values for interobserver differences in 2D measurements

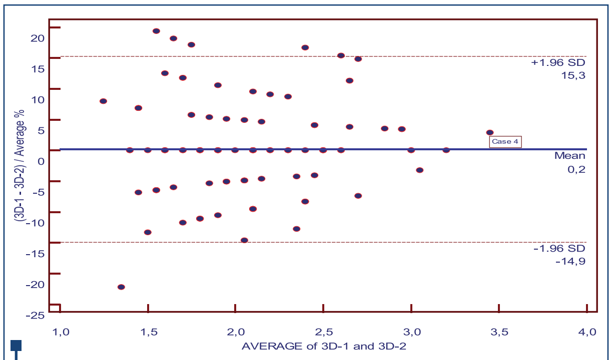

Figure 8. The corresponding values for interobserver differences in 3D measurements

Figure 9. ***2D ultrasound with sagittal section required for nasal bone measurement (pregnancy of 12 weeks and 3 days)***

Discussion

This study shows the value of 3D ultrasound for assesing and measurement of fetal nasal bones at the end of the first term pregnancy screening. Parasagittal and oblique sections obtained through 2D ultrasound as well as multislice volume processing indicate the difficulty of choice and reproducibility of the standard ultrasound image in real-time. An advantage of the first term pregnancy 3D ultrasound is represented by the possibility of further volume processing or the possibility of volume acquisition and processing to be made by different people. Disadvantages of nasal bone study on 3D volumes have been reported by Rembouskos and collaborators, who have shown the importance of the angle between the nasal bone and transducer, which must be maintained between 30-60°, at the onset of acquisition[15]. Vos and contributors[23] consider only half of the volumes acquired in 2nd and 3rd terms of pregnancy useful for the study of fetal profile and nasal bone length measured in 3D was systematically smaller than that assessed by 2D ultrasound. For the first term, Chen and collaborators[4] indicate a 79.7% percentage for highlighting of nasal bone through 3D ultrasound, but with notable differences in its measurement versus 2D ultrasound. Csapo and collaborators[7] showed increased dependence on fetal position of the multiplanar 3D image versus 2D ultrasound. Other factors influencing ideal 3D sagittal section are the interposition of limb or fetal movements. The same authors concluded that in 76.3% of volumes they identified the nasal bone and under ideal conditions of volume acquisition, the multiplanar sagittal section is clear. Borrell and collaborators[3] indicate the nasal bone view on multiplanar processed volumes in less than 78% of the acquired volumes. In order to partially overcome these under-estimated measurements, Martinez et al.[11] used the retronasal triangle in the coronal section of the fetal face for identification of the nasal bone.

The 2D ultrasound study of fetal facial bones with practical implications dates back from the early 2000s[6], when the link between nasal bone absence and trisomy 21

Figure 10. ***3D multiplanar ultrasound in the same fetus with nasal bone highlighting (top left - plane A, Sepulveda's retronasal triangle in plane B, coronal - top right-hand corner, below the transverse plane with orbits - plane C, the same pregnancy of 12 weeks and 3 days)***

was observed. Benoit and Chao[1] showed the advantage of 3D study in hypoplastic or absent nasal bone, between 17 and 33 gestational weeks.

In the late 2000s the studies of multiplanar 3D ultrasound have benefited of the fetal face by volume acquisition and processing[12,18]. This type of studies brings new data on the jaw, mandible, maxilla, and nasal-mandibular angle[8,16]. Even a diagram of the normal dimensions of fetal profile assessed through ultrasound, according to gestational age, was made[9]. According to Roelfsema and collaborators, the fetal profile analyzed through 16 parameters measured by 3D ultrasound, with composition of a variable craniofacial index, would be useful in assessing normal and abnormal fetal face[17]. Recently, Persico and collaborators have made a nasal bone length nomogram in fetuses with normal karyotype at 16-24 gestational weeks through three-dimensional ultrasound[13].

All together come in supporting our results, by using 3D ultrasound, through the main aim in trying to evaluate the nasal bones on stored volumes, i.e. from the age of 11 gestation weeks.

The data of our study are in good correlation with others[4,7], with over 80% of volumes acquired under strict conditions, and considered to be useful for nasal bone asses and measurement. Differences between operators are minimal in terms of volume assessment and measurement after processing[4,23].

Interobserver differences between the two operators are found within the range of ± 0.3 mm, at 2D measurements and 3D presenting a very small gap limits approved by 95% for 2D measurements. The measurements reproducibility were also correlated with other studies[10,22].

The intraobserver differences are found on a limit of 95% from ±0.1 mm, at the 1st operator and to ± 0.4 mm in the 2nd operator.

The corresponding values for the interobserver differences were ± 14.2% for 2D measurements, and ±15.1% for 3D measurements being still very close. The interobserver agreement of measurements for nasal bone in 3D varies from ±0.3 mm till ±15.1% for interobserver differences, showing that these values could be included as variables of relative risk Down syndrome.

Conclusions

Use of 3D multiplanar processed volumes for nasal bone measurement could represent an ideal alternative to obtaining a sagittal section by 2D ultrasound, in 80% proportion of the volumes acquired under "free face" circumstances. Dependence of volume acquisition on fetal position and lack of fetal movement makes difficult conditions for 3D ultrasound, as well as 2D sagittal section.

Further processing of the volume as well as multiplanar sections which can be replicated and standardized brings clearly useful images for fetal screening having similar results to 2D ultrasound measurement of the nasal bone. ■

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