First-Trimester Assessment of the Fetal Palate
A Novel Application of the Volume NT Algorithm

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We describe a new technique that can facilitate the first-trimester examination of the fetal palate using the Volume NT algorithm (Samsung Medison, Seoul, Korea), a program that automatically detects the exact midsagittal plane of the head and is primarily designed for semiautomatic measurement of the nuchal translucency thickness. Three-dimensional (3D) data sets from the fetal face were captured with Volume NT and subsequently reformatted with the Oblique View software to obtain orthogonal views of the primary and secondary palates in coronal and axial planes, respectively. By testing this method in selected 3D data sets obtained retrospectively (n = 12) and prospectively (n = 28), we were able to extract clinically acceptable views of the fetal palate in all cases. This preliminary report shows that with this new 3D automation development, early evaluation of the fetal palate is feasible and reproducible and could be easily incorporated into the first-trimester sonographic protocol once its ability to detect abnormal cases is demonstrated.

Key Words—cleft lip and palate; fetal face; fetal palate; fetal sonography; first trimester; prenatal diagnosis; 3-dimensional sonography

With the widespread incorporation of first-trimester sonographic screening for aneuploidy and the improving resolution of ultrasound equipment, it has become evident that the assessment of the fetal anatomy and the diagnosis of an increasing number of fetal anomalies are currently possible in early gestation. Cleft lip and palate, with a reported incidence of 1 per 800 to 1000 deliveries, is one of the most common malformations that can be detected prenatally, which has led to the recommendation of a routine examination of the upper lip at the time of the second-trimester anatomy scan. However, the systematic evaluation of the fetal secondary palate with conventional 2-dimensional sonographic technology is technically difficult and therefore not included in the guidelines for routine prenatal sonographic examinations.

The first-trimester diagnosis of cleft lip and palate has been rarely reported in the literature, mainly due to the poor familiarity with the early sonographic features associated with this condition and the lack of an established technique for evaluation. We recently described the retronasal triangle view, which simultaneously captures the alveolar ridge and the frontal processes of the maxilla in a coronal plane of the face, as an important landmark to facilitate the evaluation of the primary palate in the first trimester of pregnancy. We have also noted the possibility of digital navigation through the secondary
palate using offline analysis of 3-dimensional (3D) data sets from the fetal face in the first trimester\textsuperscript{6,7} and demonstrated the value of 3D sonography in the early diagnosis of orofacial clefts.\textsuperscript{8}

The aim of this report was to describe an even simpler, novel technique to evaluate the fetal primary and secondary palate in the first trimester of pregnancy using Volume NT (Samsung Medison, Seoul, Korea), a 3D sonographic algorithm that automatically detects and displays the exact midsagittal plane of the fetal head and is primarily designed for semiautomatic measurement of the nuchal translucency (NT) thickness.\textsuperscript{9}

Methods and Technique

For the purposes of this study, 3D data sets of the fetal face were obtained from women undergoing first-trimester sonographic examinations between 11 and 13 completed weeks. All examinations were performed transabdominally following the recommendations of the UK Fetal Medicine Foundation\textsuperscript{10,11} using high-resolution 3D ultrasound equipment (Accuvix V20 Prestige and XG; Samsung Medison) under the guidelines approved by the corresponding Institutional Review Boards. All patients provided informed consent to obtain, store, and subsequently analyze 3D data sets from their fetuses, and all examined fetuses proved to have a normal lip and palate at their subsequent second-trimester scan or at birth.

The 3D data sets were obtained by experienced operators familiar with first-trimester sonographic screening (W.S. and D.C.) as previously reported.\textsuperscript{7,8} Briefly, once the fetus was lying in the supine position, the fetal profile was identified with 2-dimensional sonography, and the fetal head was magnified until it occupied at least 75\% of the screen with the axis at 30° to 45° from the horizontal position. A mechanical probe captured the 3D data set with a 30° sweep from side to side of the face under the optimized sonographic settings available from the Volume NT software. In general terms, Volume NT acquisition is very robust and does not require precise controlled sonographic parameters other than the ones needed for first-trimester NT scanning. In addition, the exact midsagittal plane of the fetal head for obtaining the 3D data sets was not a prerequisite for acquisition, as the program automatically identifies the midsagittal plane using the software algorithm.\textsuperscript{9}

Nevertheless, as per the sonographic protocol for NT measurement,\textsuperscript{10,11} the plane selected for the original acquisition was close to the midline, avoiding the capture and subsequent reconstruction of volumes from suboptimal planes. Subsequently, by the operator placing the reference dot on the diencephalon, which appears as an anechoic structure in the center of the brain, the program automatically maps the face and locates the midsagittal plane, displaying all 3 orthogonal planes simultaneously on the screen. The resulting midsagittal plane is displayed as an enlarged image on the right panel of the screen, with both axial and coronal planes on the left panel for visual reference (Figure 1 and Video 1).

Once the final 3D data set displaying the exact midsagittal plane was obtained, the Oblique View program was activated to obtain additional simultaneous orthogonal views. Visualization of the coronal plane and identification of the retronasal triangle were attempted by drawing the reference line passing from the nasal bone area to the anterior aspect of the palate (Figure 2A). The secondary palate was examined in the axial plane by drawing the reference line all the way through the echogenic structure representing the palate (Figure 2B). The resulting orthogonal view is displayed automatically on the screen, which can be further processed as single or multiple images and as thin or thick slices using the OVIX (Oblique View Extended) display, which also allows easy navigation throughout the entire fetal palate in both the coronal and axial planes by moving the corresponding reference line on the image (Figures 3 and 4 and Video 2).

To determine the feasibility of performing the above-described technique, a total of 40 nonconsecutive 3D data sets from a similar number of first-trimester fetuses with no abnormalities were selected for analysis based on their quality in displaying the fetal profile without motion artifacts or interposition of fetal limbs. Twenty-eight of these volumes...
were obtained prospectively, and 12 were collected retrospectively from patients who had previously undergone first-trimester sonographic screening. In the latter cases, the operators were not aware of the application of the Volume NT algorithm to study the fetal palate at the time of the study. Each data set was analyzed offline by at least 2 of 3 of the authors (W.S., D.C., and J.B.).

Results

In the selected 3D data sets analyzed, the examination successfully obtained the coronal and axial planes of the fetal face and enabled an enhanced first-trimester examination of the hard palate from the loaded Volume NT data in all cases. Volume reconstruction to evaluate both the primary and secondary palate took less than 2 minutes in all cases, including magnification and optimization of the images and digital navigation through the fetal palate. The findings in relation to the identification of the primary and secondary palate were consistent between the 3 observers.

Discussion

This study demonstrates the feasibility of performing a more detailed evaluation of the fetal palate in the first trimester using 3D data sets obtained primarily for NT measurement using the Volume NT algorithm. As this technique allows automatic detection and display of the

Figure 2. Once the resulting midsagittal plane has been obtained using Volume NT, the very same 3-dimensional data set is further reformatted with the Oblique View technique to obtain the retronasal triangle in the coronal plane for evaluation of the primary palate (A) and the axial plane for evaluation of the secondary palate (B).

Figure 3. Further manipulation with the OVIX technique in the same way as in Figure 2 allows a better depiction of the primary palate (A) and the secondary palate (B) by obtaining a thick slice of the desired orthogonal plane.
midsagittal plane of the fetal face and brain, the adjunct use of any other 3D technique for reformatting the already acquired 3D data set is possible and indeed easy to perform. We found that display of the exact midsagittal plane is useful not only for a correct NT measurement but also for a more detailed examination of the fetal face, particularly the palate. A clear advantage of this technique is that it can be performed at the bedside during the allotted time for the first-trimester scan, as demonstrated by our prospective cases. In addition, volumetric data previously obtained with Volume NT can be reformatted, and a similar evaluation can be performed, as demonstrated by our retrospective cases. This capability avoids the use of more cumbersome and time-consuming computerized techniques that involve downloading the data onto a personal computer workstation, offline analysis using dedicated software programs, and considerable operator expertise with the postprocessing digital manipulation. It is also important to note that the performance in obtaining adequate views of the fetal palate from the 3D data sets obtained prospectively and retrospectively was similar. This factor may be important because retrospective volumes were obtained at a time when the operators were not aware of the potential use of Volume NT for evaluation of the fetal palate and, therefore, eliminates acquisition bias.

The prenatal diagnosis of orofacial clefts in the first trimester is challenging. One of the main limitations is the difficulty in the sonographic examination of the secondary palate, which is similar to that at more advanced gestational ages. During the first trimester, evaluation of the face and palate is indeed more challenging due to the small size of the targeted structures. These difficulties have been partially overcome with the recent advent of 3D sonography, which allows digital navigation through all the structures of the fetal face, even in the first trimester. The incorporation of new 3D automation techniques, such as Oblique View, enables the examination of volumetric data in any desired orthogonal view. The exact anatomic plane to be examined can be easily selected and displayed on the screen, thus allowing a more complete visual assessment and a better understanding of the correlation between the anatomic structures within the region of interest. On the other hand, Volume NT has been developed to provide an accurate measure of the NT thickness and therefore to reduce measurement variability. It also allows the storage of volumetric data for reassessment in all cases. As this technique is aimed to facilitate the identification of the exact midsagittal plane of the fetal face, the potential for using this very same 3D data set for assessing the fetal palate is, according to our experience, another important application of this technology. Indeed, we were able to perform a satisfactory analysis of the primary and secondary palate using the very same 3D data set initially obtained for NT evaluation in all our retrospective cases, despite the fact that the operators were not deliberately attempting to obtain good views of the palate at the time the original volume was captured. The high rate of success in achieving visualization of the palate noted in our study can be explained, at least in part, by the fact that during the first trimester the secondary palate is flat and not concave as it is at more advanced gestational ages, which favors full visualization in the multiplanar display. In addition, shadowing artifacts are usually absent due to the poor ossification of the facial bony structures, which in turn will become a considerable limitation for examining
the secondary palate later on in pregnancy. In addition, the acquisition time for capturing a volume data set from the fetal face with a 30° to 40° sweep is less than 2 seconds, which strongly reduces motion artifacts.

However, there were several limitations of our study. First, all 3D data sets used for this study were obtained by experienced operators familiar with first-trimester scanning. Although it remains to be proven whether this technique can also assist less experienced sonologists, our preliminary experience shows that once the basic technique is taught, the attainment of additional views is easy to achieve (W.S. and J.B., unpublished observations). Second, this study was performed using 3D data sets obtained from first-trimester fetuses with no abnormalities; therefore, it is still necessary to demonstrate that cleft lip and palate can indeed be diagnosed by this method. However, although our study did not include abnormal cases due to the recent incorporation of this technique into our first-trimester scanning protocol, we do not expect fetuses affected with cleft lip and palate to display features other than the ones previously reported in the first trimester using multiplanar and offline analysis of stored 3D data sets, as previously described by our group. Third, in our retrospective cases, the use of the previously stored Volume NT data, which likely represent the best 3D data sets obtained because they were obtained from data banks used for teaching and training purposes, may have contributed to the success of our technique. It is also uncertain whether this method is useful in those patients in which poor-quality 3D data sets are obtained due to the maternal habitus, abdominal scarring, or a retroverted uterus. In addition, the role of the new automation algorithms, such as Volume NT, in assisting the operator in extracting adequate palate views from 3D data sets obtained in less favorable fetal positions away from the midsagittal plane should be evaluated in properly designed studies.

In conclusion, manipulation of 3D data sets originally obtained with Volume NT and subsequently processed using Oblique View seems to be an effective technique to assess the primary and secondary palate in the first trimester. Information from this important structure is easily obtained using Oblique View, and this technique can also assist less experienced sonologists. The accuracy of this technique in the prenatal screening of cleft lip and palate is demonstrated. The feasibility of this technique in the prenatal screening of cleft lip and palate, therefore, needs to be evaluated in large prospective screening studies.

References


