Ultrasound Obstet Gynecol 2001; **18**: 481–484

Measurement of fetal nuchal translucency thickness by three-dimensional ultrasound

C. PAUL, E. KRAMPL, C. SKENTOU, D. JURKOVIC and K. H. NICOLAIDES

Harris Birthright Research Centre for Fetal Medicine, King's College Hospital, London

KEYWORDS: Down syndrome, First trimester, Nuchal translucency, Prenatal diagnosis, Three-dimensional ultrasound

ABSTRACT

Objective *To investigate the feasibility and repeatability of nuchal translucency thickness measurement using three-dimensional ultrasound.*

Methods *Forty consecutive women with uncomplicated singleton pregnancies attending for Down syndrome screening at 11–14 weeks' gestation were included in this prospective crossover trial. Nuchal translucency thickness was measured using both two-dimensional and three-dimensional ultrasound. In each case two three-dimensional volumes were recorded and then examined by using the technique of planar reformatted sections. The initial plane of the first volume always contained a clear image of the nuchal region ('sagittal volume'), whilst the initial plane of the second volume was selected randomly regardless of fetal position ('random volume'). The repeatability of nuchal translucency measurement was examined by constructing a scatter diagram of the difference between the measurements plotted against the mean of two readings.*

Results *Nuchal translucency measurements could be repeated in 38/40 (95%) sagittal volumes and 24/40 (60%) random volumes. The mean difference between two-dimensional measurements and those obtained by reslicing of sagittal three-dimensional volumes was –0.097 mm (95% limits of agreement from –0.481 to 0.675) and 0.225 mm (95% limits of agreement from –0.369 to 0.819) when random volumes were examined.*

Conclusions *Reslicing of stored three-dimensional volumes can be used to replicate nuchal translucency measurements only when nuchal skin can also be clearly seen on two-dimensional ultrasound.*

INTRODUCTION

Nuchal translucency measurement has become a standard technique in many obstetric units for the risk assessment of chromosomal abnormality[1,2]. Although nuchal translucency measurements can be completed without difficulty in most cases, the success rates vary between different centers[3–5]. These variations have been attributed mainly to the differences in the sonographers' training[6]. Other possible factors affecting the success in obtaining the measurement are variations in quality of the ultrasound equipment, route of examination (transabdominal or transvaginal) and the gestational age at which the measurement is attempted[7]. However, even in optimal conditions the examination may occasionally take a long time to complete when the fetus is lying in an unfavorable position.

It has recently been suggested that three-dimensional ultrasound may help to overcome some of these problems[8,9]. This new technique enables a fast acquisition of a large number of two-dimensional ultrasound sections using a scanner which monitors the spatial orientation of the images. The scans are then stored in the machine's computer memory in the form of a volume set. The stored ultrasound data may be resliced in any desired plane thus providing the views of the organ of interest which could not be seen on conventional two-dimensional scan. Theoretically, this may enable measurements of nuchal translucency to be performed regardless of the fetal position, which could significantly shorten the examination time. In addition, by displaying three orthogonal planes at the same time, the use of three-dimensional ultrasound may ensure that the measurements are always performed in the true mid-sagittal plane.

The aim of this study was to investigate the feasibility and repeatability of nuchal translucency measurements using commercially available three-dimensional ultrasound equipment. In addition we examined whether measurements in the true mid-sagittal plane differ significantly from the results obtained on two-dimensional scans.

METHODS

Healthy pregnant women attending for nuchal translucency screening at 11–14 weeks' gestation were invited to join the study. All examinations were performed by two experienced

Correspondence: Dr D. Jurkovic, Early Pregnancy and Gynaecology Assessment Unit, Department of Obstetrics and Gynaecology, King's College Hospital, Denmark Hill, London SE5 9RS, UK (e-mail: davor.jurkovic@kcl.ac.uk)

Received 1-3-01, Revised 25-5-01, Accepted 2-8-01

observers (C.P. and E.K.), who were both holders of The Fetal Medicine Foundation Certificate of Competence in The 11–14-week Scan. A single examiner performed both two-dimensional and three-dimensional scans in each individual case. A standard two-dimensional real-time transabdominal scan was performed first using a 5-MHz probe (Combison 530, Kretz Technik, Zipf, Austria). The nuchal translucency was measured in the sagittal section of the fetus. The maximum thickness of the subcutaneous translucency between the skin and the soft tissue overlying the cervical spine was measured. Care was taken to distinguish between fetal skin and the amniotic membrane as, at this gestation, both structures appear as a thin membrane. To achieve this it was sometimes necessary to wait for spontaneous fetal movement away from the amniotic membrane. Alternatively the fetus was bounced off the amnion by asking the mother to cough, or by tapping the maternal abdomen. The calipers were placed on the inner aspect of the thin echogenic lines defining the nuchal translucency and the maximum of three measurements was recorded as the final reading.

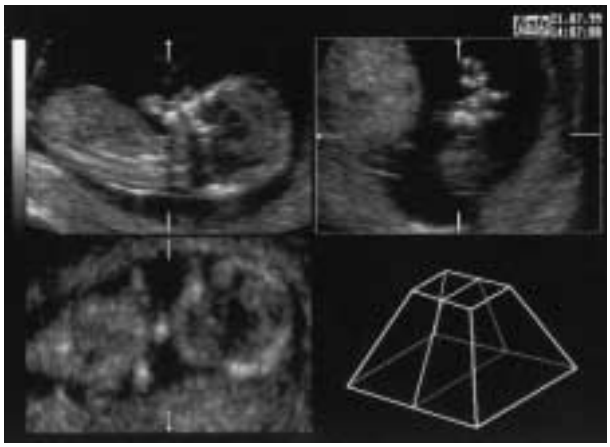

Figure 1 Illustration of nuchal translucency measurement using three-dimensional ultrasound. The sagittal volume was recorded when the fetus was in an acceptable position to take a nuchal translucency measurement on two-dimensional scan (upper left image).

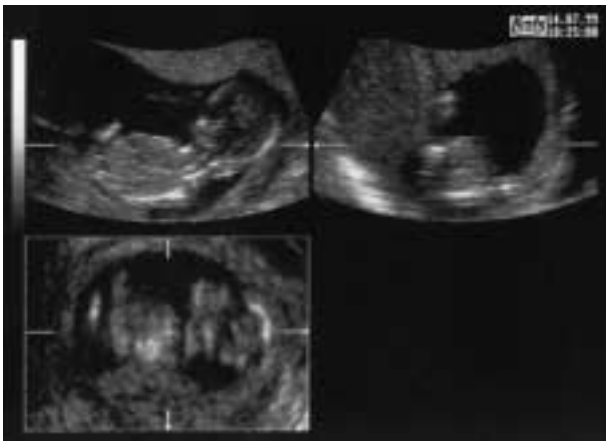

Figure 2 An example of random volume. The initial plane from which the volume was recorded was selected randomly with no efforts being made to optimize the angle between the fetus and the ultrasound beam (upper left image).

After routine nuchal translucency measurements had been completed, two three-dimensional ultrasound volumes were generated and stored for further analysis. The procedure for volume acquisition has been described previously[10]. The first volume ('sagittal volume') was recorded when the fetus was in an acceptable position to take a nuchal translucency measurement by two-dimensional ultrasound (Figure 1). The second volume ('random volume') was recorded ensuring only that the whole of the fetus was included in the volume. The initial plane from which the volume was recorded was thus selected randomly with no efforts being made to optimize the angle between the fetus and the ultrasound beam (Figure 2). All volumes with gross movement artefacts were discarded and the procedure of volume acquisition was repeated.

The volumes were stored and analyzed once the data collection had been completed. Thus the examiners were unaware of the measurements obtained at the initial two-dimensional scan. The volume analysis was performed using the technique of planar reformatted sections. First the overall image quality of three-dimensional volumes was assessed and the presence of any movement artefacts was noted. The measurements of nuchal translucency were then performed on the stored volumes and the results were compared to two-dimensional readings. The sagittal volumes were also examined for the differences between the best obtainable plane on two-dimensional scan and measurements in the true mid-sagittal section performed on three-dimensional scan.

The repeatability of nuchal translucency measurements was examined by constructing a scatter diagram of the difference between the measurements plotted against the mean of the two readings[11].

RESULTS

The study included 40 women with singleton pregnancies at a median gestational age of 12 (range, 11–14) weeks. There were no detectable fetal structural defects and nuchal translucency was successfully measured in all cases on two-dimensional real-time ultrasound. The nuchal thickness ranged between 0.7 and 2.1 mm.

By reslicing sagittal three-dimensional volumes, nuchal translucency measurements could be repeated in 38/40 (95%) cases. In two cases it was impossible to differentiate between the skin and amniotic membrane. The mean difference between two-dimensional and three-dimensional measurements was −0.097 mm (95% limits of agreement from −0.481 mm to 0.675 mm) (Figure 3).

Further analysis of sagittal volumes revealed that 28/38 (74%) original nuchal translucency measurements were not performed in the true mid-sagittal section. The mean difference between the original measurement and the measurement in the true mid-sagittal section was −0.008 mm (95% limits of agreement from −0.386 to 0.37 mm) (Figure 4).

Reslicing of random volumes enabled successful nuchal translucency measurements in 24/40 (60%) women. The measurements of nuchal translucency performed on random

volumes were lower compared to the original two-dimensional readings (mean difference, 0.225; 95% limits of agreement from −0.369 to 0.819; Figure 5).

The mean time necessary to complete the two-dimensional measurement was 97 (range, 30–360) s. Acquisition of sagittal volumes took significantly longer (mean, 209 s; range, 30–600 s; $t = 3.16$, $P < 0.01$), whilst random volumes were all collected within 60 s.

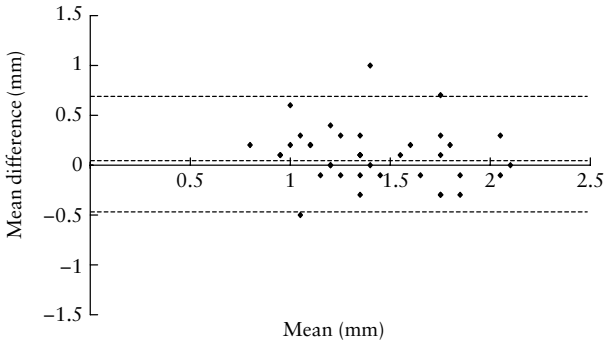

Figure 3 Mean differences between nuchal translucency measurements on two-dimensional scan and on sagittal three-dimensional ultrasound volumes plotted against the mean of the two measurements, with limits of agreement.

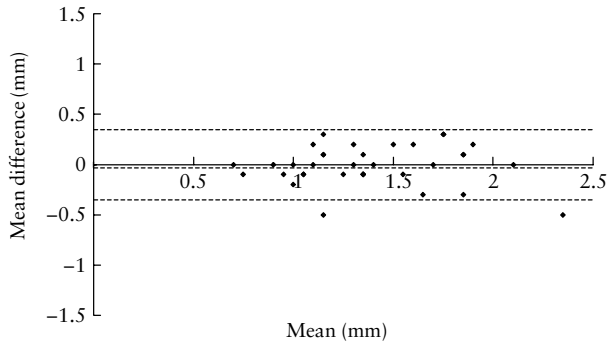

Figure 4 Mean differences between nuchal translucency measurements performed in the best obtainable plane on two-dimensional scan and the true mid-sagittal section obtained by reslicing of the sagittal three-dimensional ultrasound volumes plotted against the mean of the two measurements, with limits of agreement.

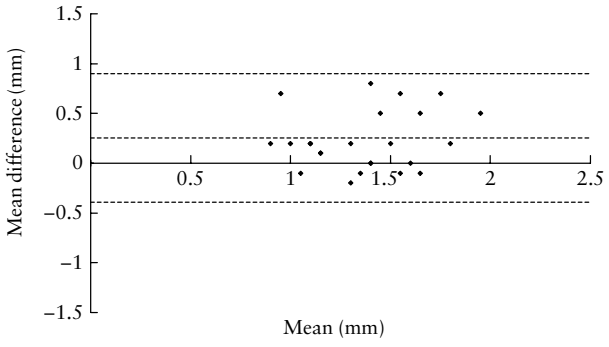

Figure 5 Mean differences between nuchal translucency measurements on two-dimensional scan and on reslicing of random three-dimensional ultrasound volumes plotted against the mean of the two measurements, with limits of agreement.

DISCUSSION

This study showed that nuchal translucency measurements could be accurately replicated on stored three-dimensional ultrasound volumes. Therefore, theoretical concerns that subtle movement artefacts caused by maternal heart pulsations could distort three-dimensional volumes and affect accuracy of nuchal translucency measurements were not substantiated by our results. We also showed that the majority of two-dimensional nuchal translucency measurements were not performed in the true mid-sagittal plane. However, the mean difference between measurements in the true mid-sagittal and in other planes was very small; it would therefore be possible to calculate the risk for trisomy 21 with three-dimensional ultrasound by using the same approach to risk assessment as with conventional two-dimensional scanning.

It has to be emphasized that three-dimensional measurements could be performed successfully only by examination of sagittal volumes which contained a clear view of the nuchal translucency in the initial plane. In this situation the measurement could also be completed without difficulty on two-dimensional scan. Our results also show that the examination is faster when two-dimensional ultrasound is used. Fetal movements, which occur often at this gestation, facilitate differentiation between the nuchal skin fold and the amniotic membrane on real-time two-dimensional scan. A three-dimensional scan, on the contrary, can only be successfully performed when the fetus is resting. This prolongs the examination time and decreases the success rate of obtaining a clear view of the nuchal fold as happened in two of our cases.

The examination of random three-dimensional volumes was unsuccessful in 40% of cases. Failure to obtain measurements regularly occurred with the fetal long axis lying parallel to the ultrasound beam. The measurements were also unsuccessful when the fetal sagittal plane was lying perpendicular to the ultrasound beam. In both positions the skin covering the cervical spine was positioned parallel to the ultrasound beam which prevented clear visualization of the nuchal translucency on both two- and three-dimensional scans.

The main theoretical advantage of using three-dimensional ultrasound would be in cases when nuchal translucency measurement cannot be completed due to an unfavorable fetal position. The ability to overcome this problem by rotating and reslicing three-dimensional volumes would be of great help in clinical practice. Unfortunately, our study showed conclusively that the quality of a three-dimensional ultrasound examination is determined by the clarity of the two-dimensional images constituting the volume, which cannot be improved by subsequent manipulation.

Our results differ from those of two previous studies, which suggested that three-dimensional ultrasound is likely to improve the accuracy of nuchal translucency measurements in the future. In their study, Kurjak *et al.*[8] examined the reproducibility of nuchal translucency measurement using the transvaginal approach. They obtained satisfactory views of the nuchal region in 85% of examinations performed by

two-dimensional ultrasound and in 100% when three-dimensional ultrasound was used. However, two-dimensional and three-dimensional examinations were performed by different operators, which may have influenced the success rate. In addition, three-dimensional volumes were recorded only when a clear view of the nuchal translucency was obtained on two-dimensional scan, rather than using the technique of random volume as was the case in our study.

A study by Chung *et al.*[9] also recorded three-dimensional volumes only when a clear view of nuchal fold was seen on the initial two-dimensional scan. They did not attempt to compare the results of three-dimensional scans with measurements obtained on two-dimensional scan. Therefore, this study does not provide any information on the accuracy or repeatability of nuchal translucency thickness measurements by three-dimensional ultrasound, neither does it assess the potential role of three-dimensional ultrasound in situations when measurements cannot be completed on two-dimensional scans.

In conclusion, our study confirms that reslicing of stored three-dimensional ultrasound volumes can be used to replicate nuchal translucency measurements when nuchal skin can be clearly seen on two-dimensional scan as well. However, when the fetus is lying in a position which precludes clear visualization of the nuchal fold, three-dimensional ultrasound is unlikely to be of help. This severely limits the potential role of this new technique in the screening for Down syndrome in the first trimester of pregnancy.

REFERENCES

1 Snijders RJM, Noble P, Sebire N, Souka A, Nicolaides KH. UK multicentre project on assessment of risk of trisomy 21 by maternal age and fetal nuchal translucency thickness at 10–14 weeks of gestation. *Lancet* 1998; 351: 343–6
2 Thilaganathan B, Slack A, Wathen NC. Effect of first-trimester nuchal translucency on second-trimester maternal serum biochemical screening for Down's syndrome. *Ultrasound Obstet Gynecol* 1997; 10: 261–4
3 Economides DL, Whitlow BJ, Kadir R, Lazanakis M, Verdin SM. First trimester sonographic detection of chromosomal abnormalities in an unselected population. *Br J Obstet Gynaecol* 1998; 105: 58–62
4 Kornman LH, Morssink LP, Beekhuis JR, DeWolf BTHM, Heringa MP, Mantiangh A. Nuchal translucency cannot be used as a screening test for chromosomal abnormalities in the first trimester of pregnancy in a routine ultrasound practice. *Prenat Diagn* 1996; 16: 797–805
5 Taipale P, Hiilesmaa V, Salonen R, Ylostalo P. Increased nuchal translucency as a marker for fetal chromosomal defects. *N Engl J Med* 1997; 337: 1654–8
6 Pandya PP, Altman D, Brizot ML, Pettersen H, Nicolaides KH. Repeatability of measurement of fetal nuchal translucency thickness. *Ultrasound Obstet Gynecol* 1995; 5: 334–7
7 Braithwaite JM, Economides DL. The measurement of nuchal translucency with transabdominal and transvaginal sonography—success rates, repeatability and levels of agreement. *Br J Radiol* 1995; 68: 720–3
8 Kurjak A, Kupesic S, Ivancic-Kosuta M. Three-dimensional transvaginal ultrasound improves measurement of nuchal translucency. *J Perinatal Med* 1999; 27: 97–102
9 Chung BL, Kim HJ, Lee KH. The application of three-dimensional ultrasound to nuchal translucency measurement in early pregnancy (10–14 weeks): a preliminary study. *Ultrasound Obstet Gynecol* 2000; 15: 122–5
10 Zosmer N, Jurkovic D, Jauniaux E, Gruboeck K, Lees C, Campbell S. Three-dimensional fetal echocardiography. Identification of standard cardiac views on planar reformatted sections. *J Ultrasound Med* 1996; 16: 10–5
11 Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* 1986; 1: 307–10