Diagnostic Accuracy of Nuchal and Intracranial Translucency by Two-dimensional versus Three-dimensional Ultrasonography in Low-Risk Pregnancy

Abstract

Background: First-trimester ultrasound was initially done for confirming pregnancy, counting fetuses, and dating. Later, combined trisomy 21 screening became crucial, Nuchal Translucency (NT), measured at 11-13 weeks + 6 days, indicates chromosomal defects with increased thickness. It's an effective marker for trisomies, triploidy, Turner syndrome, and congenital heart defects. More over, intracranial translucency (IT) assessment is a useful tool for prediction NTDs.

Aim of study: The aim was to evaluate the diagnostic accuracy of nuchal and intracranial translucency assessment by two-dimensional (2D) versus three-dimensional (3D) ultrasonography in low-risk pregnancy at the first trimester.

Patients and methods: This study was a Cross sectional study conducted at Outpatient clinic at obstetrics and gynecology department at Mansoura University Hospital from May 2021 to May 2022. Study population included 30 Low risk pregnant women with their gestational ages ranging from 11-13 weeks and six days.

Results: there was no statistically significant difference in assessment the NT and IT by 2D ultrasound and 3D ultrasound.

Conclusion: There was a complete matching between 2D and 3D ultrasound in detection of IT and NT in low-risk pregnancy at the first trimester.

Keywords: Nuchal Translucency; 3D ultrasonography; pregnancy.

INTRODUCTION

In the introduction of routine first trimester ultrasound for prenatal care, the focus was primarily on confirming pregnancy, viability, fetus count, and accurate dating. However, as prenatal care evolved in the late 1990s to include combined screening for trisomy 21, using nuchal translucency (NT) measurements and assessment of early fetal anatomy became a crucial part of first trimester
imaging. This detailed examination now has the potential to detect around 50% of major structural anomalies.\textsuperscript{1}

The NT is a measure of fluid accumulation behind the fetal neck during the first trimester between 11 and 13 weeks and 6 days gestation, with a minimum fetal crown-rump length (CRL) of 45 mm and a maximum of 84 mm. An increase in NT thickness during this period is associated with major chromosomal defects, Median and 95th centile NT values at CRL of 45 mm are 1.2 and 2.1 mm, while at CRL of 84 mm, they are 1.9 and 2.7 mm.\textsuperscript{2}

Studies have highlighted the effectiveness of specific ultrasound markers, such as NT, nasal bone, long bone biometry, and ductus venosus Doppler assessment, for screening trisomies, triploidy, Turner syndrome, and congenital heart defects. An NT thickness exceeding 2.5 mm between 10 and 13 weeks and 6 days is linked to an increased risk of these conditions.\textsuperscript{3}

Normal fetuses display an intracranial translucency (IT) parallel to the NT, while fetuses with open spina bifida may lack IT.\textsuperscript{4}

The best time to measure fetal IT is between 11 and 13 weeks and 6 days.\textsuperscript{5}

The anteroposterior diameter of IT increases with fetal CRL within the 11-13 week range, from 1.5 mm at a CRL of 45 mm to 2.5 mm at a CRL of 85 mm.\textsuperscript{6}

Moreover, measuring IT has proven valuable for the early detection of neural tube defects (NTDs).\textsuperscript{7}

Early identification of NTDs can aid in decision-making, as some cases may benefit from fetal surgery. Therefore, offering screening for NTDs as part of routine first-trimester scan is crucial.\textsuperscript{8}

Overall, sonographic examination of NT and IT between 11 and 13+6 weeks of gestation is recommended as a screening method for chromosomal anomalies, and NTDs.\textsuperscript{9}

Therefore, the present study was carried out to evaluate the diagnostic accuracy of (NT) and (IT) assessment by two-dimensional (2D) versus three-dimensional (3D) ultrasonography in low-risk pregnancy at first trimester.

**Patients and Methods**

This study was a Cross sectional study conducted at Outpatient clinic at obstetrics and gynecology department at Mansoura University Hospital from May 2021 to May 2022.

**Study population:** Low risk 30 pregnant women with gestational ages ranging from 11–13 weeks and six days.

**Inclusion criteria:** young age below 35 years old with No history of chronic disease.

**Exclusion criteria:** Multiple pregnancies, history of recurrent miscarriage, family history of fetal anomalies, past history of previous sibling with congenital anomaly, history of consanguinity. As well as Patient refusal

**All patients enrolled in this study had the following:**

- Verbal consent was obtained from the pregnant women participate of the study
- Every participated was subjected to a full history taking and General examination was carried out for pulse, blood pressure, temperature, BMI (height and weight), abdominal examination, Obstetric examination were also carried out if needed Relevant investigations were done such as Complete blood count (CBC), prothrombin time (PT) and blood sugar and urine analysis.
- Method of Ultrasound examination: Women at 7 to 10 weeks' gestation initially had an abdominal ultrasound to confirm pregnancy viability, gestational age, and singleton pregnancy. For abdominal scans, patients lay supine with a full bladder, The Samsung-H60 ultrasound
system was employed, Transvaginal scans were used when needed for better fetal structure imaging or when structural anomalies were suspected.

- Detailed ultrasound was performed at 11-13 weeks + 6 days for fetal viability, CRL, fetal position, NT and IT
- Fetal medicine foundation (FMF) protocol for measurement of NT. The gestational age of examination was must be 11-13 weeks and six days. The fetal (CRL) ranged from 45 to 84 mm. image magnified covers the fetal head and thorax entirely. mid-sagittal view was obtained the face, defined by specific facial features. With the fetus in neutral position and the head aligned with the spine. fetal skin and amnion was distinguished. the widest part of translucency was measured. NT measurements, IT presence, and IT antero-posterior diameter.
- measurement of the IT has been previously described as a useful US marker for the early detection of NTDs .10
- After 2D-NT measurement, 3D volume acquisition was performed. A 3D sweep encompassing the fetal head and upper thorax was stored for later use.

Unsuccessful 3D volume acquisition, due to fetal position or movement issues within 15 minutes, led to exclusion from the study .11

- Data Management and Analysis The collected data were analyzed using the SPSS (Statistical Package for Social Sciences) version 27 for Windows® (IBM SPSS Inc, Chicago, IL, USA). The comparison between two groups was done by using Chi-square test. The comparison between two independent groups was done by using independent t-test.

RESULTS

There was no statistically significant difference among the participant of the study regarding their age, BMI, Parity and gravidity with mean age of the studied cases of about 27.10 ± 3.49 years, and mean body mass index of about 27.91 ± 2.74 kg/m². There was a statistically significant positive correlation between NT measured by 2D (mm) with CRL (rs= 0.559, p= 0.001). Moreover, there was a statistically significant positive correlation between NT by 2D (mm) with GA (rs= 0.495, p= 0.005) (As showed by Table 1).

Table (1): Correlation of NT by 2D with other variables.

<table>
<thead>
<tr>
<th>NT by 2D (mm)</th>
<th>rs</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>0.342</td>
<td>0.065</td>
</tr>
<tr>
<td>Weight (Years)</td>
<td>-0.154</td>
<td>0.416</td>
</tr>
<tr>
<td>Height (Cm)</td>
<td>0.118</td>
<td>0.534</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>-0.100</td>
<td>0.597</td>
</tr>
<tr>
<td>Gravidity</td>
<td>0.175</td>
<td>0.354</td>
</tr>
<tr>
<td>Parity</td>
<td>0.376</td>
<td>0.041*</td>
</tr>
<tr>
<td>GA (Days)</td>
<td>0.495</td>
<td>0.005*</td>
</tr>
<tr>
<td>CRL (mm)</td>
<td>0.559</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

rs: Spearman’s correlation; P: Probability; *: statistically significant (P ≤ 0.05); CRL: Crown-rump length; GA: Gestational age.
There was a statistically significant positive correlation between NT measured by 3D with CRL \((rs = 0.559, p = 0.001)\) as well as GA \((rs = 0.509, p = 0.004)\) (As showed by Table 2).

**Table 2: Correlation of NT by 3D with other variables.**

<table>
<thead>
<tr>
<th>variable</th>
<th>(r)</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>0.319</td>
<td>0.085</td>
</tr>
<tr>
<td>Weight (Years)</td>
<td>-0.144</td>
<td>0.448</td>
</tr>
<tr>
<td>Height (Cm)</td>
<td>0.086</td>
<td>0.651</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>-0.074</td>
<td>0.696</td>
</tr>
<tr>
<td>Gravidity</td>
<td>0.182</td>
<td>0.336</td>
</tr>
<tr>
<td>Parity</td>
<td>0.351</td>
<td>0.057</td>
</tr>
<tr>
<td>GA (Days)</td>
<td>0.509</td>
<td>0.004*</td>
</tr>
<tr>
<td>CRL (mm)</td>
<td>0.559</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

BMI: Body mass index; CRL: Crown-rump length; GA: Gestational age; NT: Nuchal translucency; P: Probability; rs: Spearman’s correlation; *: statistically significant \((P \leq 0.05)\).

interclass agreement coefficient between NT by 2D (mm) and NT by 3D (mm) was 0.991 (CI: 0.995) and this agreement showed high statistically significant value \((p < 0.001)\) (As showed by Table 3).

**Table (3): Agreement analysis (Interclass correlation) in detection**

<table>
<thead>
<tr>
<th></th>
<th>Agreement coefficient (Interclass correlation)</th>
<th>95% CI</th>
<th>(P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT by 2D (mm) and NT by 3D (mm)</td>
<td>0.991</td>
<td>0.995</td>
<td>&lt; 0.001*</td>
</tr>
</tbody>
</table>

of NT by 2D and 3D ultrasound.

CI: Confidence interval; *: Statistically significant \((p < 0.05)\).

There was a complete matching between the 2D and 3D ultrasound in detection of IT (Table 4).

**Table (4) Agreement between 2D and 3D ultrasound in detection of IT.**

<table>
<thead>
<tr>
<th>variables</th>
<th>IT by 2D N = 30</th>
<th>IT by 3D N = 30</th>
<th>Test of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
<td>%</td>
<td>No.</td>
</tr>
<tr>
<td>IT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
<td>2</td>
<td>6.7%</td>
<td>2</td>
</tr>
<tr>
<td>Present</td>
<td>28</td>
<td>93.3%</td>
<td>28</td>
</tr>
</tbody>
</table>

Demographic data expressed as Number (%); \(k\): Kappa agreement coefficient; *: Statistically significant

at 11-13 + 6d was 1.56 ± 0.37 mm that was statistically significantly lower as compared to the cases with abnormal scan \((5.39 ± 0.30\) mm) \((P < 0.001)\). The mean NT by 3D in the cases with normal results of scan at 11-13 + 6d was 1.68 ± 0.35 mm that was statistically significantly lower as compared to the cases with abnormal scan \((5.39 ± 0.30\) mm) \((P < 0.001)\), **Fig (2 & 3)** (As showed by Table 5).
Table (5): Relation between scan at 11-13 + 6d and NT by 2D & NT by 3D.

<table>
<thead>
<tr>
<th>Scan at 11-13 + 6d</th>
<th>Normal (N=28)</th>
<th>Abnormal (N=2)</th>
<th>Test of significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>NT by 2D (mm)</td>
<td>1.56 ± 0.37</td>
<td>5.39 ± 0.30</td>
<td>t= -14.388 P &lt; 0.001*</td>
</tr>
<tr>
<td>NT by 3D (mm)</td>
<td>1.68 ± 0.35</td>
<td>5.39 ± 0.30</td>
<td>t= -14.509 P &lt; 0.001*</td>
</tr>
</tbody>
</table>

NT: Nuchal translucency; t= independent samples t-test; χ²= Chi-square test

showed that the interclass agreement coefficient scan time by 2D (min) and scan time by 3D (min) is 0.555 (CI: 0.249-0.760) and this agreement showed statistically significant value (p= 0.002). (As showed by Table 6)

Table (6): Agreement analysis (Interclass correlation) between 2D and 3D regarding the time of scanning.

<table>
<thead>
<tr>
<th>Scan time</th>
<th>Agreement coefficient (Interclass correlation)</th>
<th>95% CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>by 2D (min) and 3D (min)</td>
<td>0.555</td>
<td>0.249-0.760</td>
<td>0.002*</td>
</tr>
</tbody>
</table>

CI: Confidence interval; *: statistically significant (P ≤ 0.05).

Transvaginal approach was carried out for assessment of NT in 5 cases of the study for technical difficulties.

Figure (2): Case of cystic hygroma abnormal NT 5.18 mm and absent of IT.

Figure (1): Normal NT and IT by 3D ultrasound.

Figure (3): Normal NT and IT with 2D ultrasound.
DISCUSSION

The aim of this study was to detect the diagnostic accuracy of NT and IT by 2D versus 3D ultrasonography in low-risk pregnancy. In the current study, there were two women with Abnormal Scan and 28 were normal Scan (mean 6.66) and the CRL (mm) ranged from 46 to 91 mm (mean 64.43mm) and the G.A ranged from 11 weeks to 13 days. The mean NT by 2D was 1.82 ± 1.03 mm while the mean NT by 3D was 1.93 ± 1.00 mm.

This was in accordance with Khalifeh et al. .12 who included 366 patients with singleton pregnancies at a mean GA of 12.3 weeks) and a mean CRL of 58 mm. NT ranged from 0.8 to 2.9 mm. 2D NT was obtained in 359 (98%) patients, while 3D NT in sagittal planes was obtained for all 359 patients. 3D NT measurements in axial planes were obtained in 322 patients (88%). The mean maximal NT measurement for 2D, 3D sagittal, and 3D axial planes were 1.65 (± 0.34), 1.70 (± 0.42), and 1.66 mm (± 1.28), respectively.

This was in accordance with Dinç and Eyüboğlu .13 who showed that in the First trimester screen was done in 1640 singleton pregnancies. The measurements were performed on 1541 (%94) fetuses by the transabdominal route and on 99 cases (%4) by the transvaginal route. The mean NT measurements at 11–11+6, 12–12+6, and 13–13+6 gestational weeks were 1.40 ± 79 mm, 1.58 ± 0.76 mm, and 1.68 ± 0.64 mm, respectively. NT thickness for the 95th, 97th, and 99th percentiles were 2.82 mm, 3.17 mm, and 4.75 mm, respectively.

Also, the current results agreed those of Lec et al. .14 who retrospectively analyzed the IT of 93 singleton fetuses. They showed that the median GA was 11.6 weeks, and the mean CRL was 54.0 ± 7.4 mm. All fetuses appeared normal on their second trimester scan.

The mean NT thicknesses in Caucasian, African, Asian, and Caribbean populations were 1.54 mm, 1.48 mm, 1.61 mm, and 1.51 mm respectively.15

In the current study, there was a complete matching between the 2D and 3D ultrasound in detection of IT that was detected in 28 cases (93.3%) by both techniques.

This disagreed with the study by Mein et al. .16 that included the analysis of data of four operators of 173 women who attended the Perinatal Ultrasound Department for their NT scan, at which time a 2D measurement of IT was recorded. A 3D sweep of the fetal brain was also performed on the same patient by a qualified sonographer. There is a low level of agreement, an inter-rater correlation coefficient (ICC) =of about 0.227, 95% CI (0.15, 0.313). The average 3D measurement correlated poorly with the 2D gold standard, ICC=of about 0.22, 95% CI (0.076, 0.355).

This variation could be attributed to the nature of data representation, as previous study used the numerical values which could affect the degree of agreement based on minor variations, especially with the increased sample size.

In the current study, the interclass agreement coefficient between NT by 2D (mm) and NT by 3D (mm) was 0.991 (CI: 0.980-0.995) and this agreement showed high statistically significant value (p<0.001).

This was in accordance with Khalifeh et al. .12 who showed that the Spearman rank correlation (r) of 2D sagittal plane sonography with 3D sagittal and axial plane sonography was 0.73 and 0.68, respectively (p <0.001).

Similar results were shown by Wce et al. .3 who conducted a study on a total number of 23 patient. The results showed that there was a strong positive linear relationship between 3D and 2D-NT measurements within Pearson's correlation coefficient values, R = 0.861. as 2D-NT measurement increases, 3D-NT measurement increases as well. The computed linear regression line equation was 3D_NT = (0.945)2D-NT - 0.013.

Furthermore, the current study agreed with those of Cho et al. .16 who included 114 cases in their study. NT measurement was successful by the conventional 2D method in 95.6% (109/114) of cases and by 3D and Volume NTTM measurements in 103 and 93 cases, respectively. Success rate was not significantly different between methods. In 89 cases, NT values were available using all three methods. Among them, mean ± SD
2D-NT was 1.3 ± 0.4 mm, 3D-NT was 1.2 ± 0.4 mm and Volume NTTM was 1.3 ± 0.4 mm. The mean differences of the intra- and interobserver variability of each method were not significantly different from zero for each method.

In the study by Kurjak et al., 17 examinations were performed on 120 women undergoing ultrasound screening at 10 to 14 weeks' gestation. They were examined by two experienced ultra-sonographers using both methods two times consecutively. Statistical analysis for the assessment of intra-observer reproducibility was paired t-test. NT measurements were obtained in 100% of cases with three-dimensional sonography compared to only 85% with two-dimensional sonography. Better intra-observer reproducibility was obtained for three-dimensional than for two-dimensional ultrasound. Three-dimensional transvaginal ultrasound improves accuracy of NT measurement allowing appropriate mid-sagittal section of the fetus and clear distinction of the nuchal region from the amniotic membrane.

On the other hand, the study of Antsaklis et al., 18 used 199 patients were included in that study suggests that the 3D ultrasound examination was insufficient to perform the fetal anatomy required in the 1st trimester of pregnancy. In a significant percentage of the cases, examination of the anatomical parameters could not be performed at all, or their assessment deviated from the clinically acceptable level. The mean NT measured by 2D was 1.65 ± 0.33 mm while the mean NT by 3D was 1.19 ± 0.63 mm.

In the current study, there was a statistically significant moderate positive correlation between NT by 2D (mm) with CRL \((r_s = 0.559, p = 0.001)\). Moreover, there was a statistically significant moderate positive correlation between NT by 2D (mm) with GA \((r_s = 0.495, p = 0.005)\). Also, there was a statistically significant moderate positive correlation between NT by 3D (mm) with CRL \((r_s = 0.559, p = 0.001)\). Moreover, there was a statistically significant moderate positive correlation between NT by 3D (mm) with GA \((r_s = 0.509, p = 0.004)\).

With the study conducted by Dinç and Eyüboğlu İL. 19 who showed that there was a significant and positive correlation between NT and CRL \((r = 0.131 \text{ and } P < 0.001)\)

In their study, Wee et al., 3 showed that the Pearson's correlation between GA and CRL with 3D-NT measurements, at values R = 0.005 and 0.017 respectively. Also, their Results showed that 3D-NT variables had positive relationship with GA and CRL.

Chen and et al. (2012) 20 reported similar conclusions, where they showed that at 11 to 13 + 6 weeks of gestation the IT anterior and posterior diameter at first trimester ranged from 1.35 to 2.6 mm as the CRL increased from 45 to 84 mm.

The main Drawbacks of current study was relative small sample size need large scale studies for fortification of results.

**CONCLUSION**

There was a complete matching between 2D and 3D ultrasound in detection of IT and NT in low-risk pregnancy at the first trimester. No difference in NT by 2D or 3D according to the scanning approach either transabdominal alone or both transabdominal and transvaginal together. We suggest that 3D ultrasound is an effective means of assessment of NT & IT and offers some potential advantages over 2D ultrasound.

**References**


19. Dinç GÜ, Eyüboğlu İL. Distribution of nuchal translucency thickness at 11 to 14 weeks of gestation in a normal Turkish population. Turkish Journal of Medical Sciences. 2021;51(1):90–94.