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Frontomaxillary facial angle in fetuses with spina bifida at 11–13 weeks' gestation

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KEYWORDS: first-trimester screening; frontomaxillary facial angle; neural tube defect; spina bifida

ABSTRACT

Objective *To determine whether in fetuses with open spina bifida at 11–13 weeks' gestation the frontomaxillary facial angle is decreased.*

Methods *The frontomaxillary facial angle was measured in 20 fetuses with open spina bifida and in 100 normal controls matched for crown–rump length (CRL) at 11 + 0 to 13 + 6 weeks and the values in the two groups were compared.*

Results *In the control group the frontomaxillary facial angle decreased significantly with CRL from a mean of 84.0° at a CRL of 45 mm to 76.5° at a CRL of 84 mm (SD, 3.26°). In the spina bifida group the mean frontomaxillary facial angle, corrected for CRL, was 9.9° lower than in the controls and it was below the 5th centile in 18 (90%) of the cases (*$P < 0.0001$*).*

Conclusions *In fetuses with open spina bifida at 11–13 weeks' gestation the frontomaxillary facial angle is decreased and this measurement may be useful in early screening for this abnormality. Copyright © 2010 ISUOG. Published by John Wiley & Sons, Ltd.*

INTRODUCTION

The frontomaxillary facial angle, between the upper surface of the palate and the frontal bone in a mid-sagittal view of the fetal face, is a sonographic parameter that provides an objective measurement of the position of the anterior end of the maxilla to the forehead[1]. In normal fetuses at 11–13 weeks' gestation the frontomaxillary facial angle decreases with fetal crown–rump length (CRL) from a mean of about 85° at a CRL of 45 mm to 75° at a CRL of 84 mm[2]. In fetuses with trisomy 21 the frontomaxillary facial angle is increased and this is thought to be due to hypoplasia or posterior displacement of the palate[1,3].

Open spina bifida is associated with the Arnold–Chiari malformation, which is thought to be the consequence of leakage of cerebrospinal fluid into the amniotic cavity and hypotension in the subarachnoid spaces leading to caudal displacement of the brain and obstructive hydrocephalus. In the second trimester of pregnancy the manifestations of the Arnold–Chiari malformation are the 'lemon' and 'banana' signs, and in the first trimester caudal displacement of the brain results in compression of the fourth ventricle[4–7].

The aim of this study was to determine whether, in fetuses with open spina bifida at 11–13 weeks, the Arnold–Chiari malformation results in caudal displacement of the forehead relative to the position of the anterior end of the maxilla and therefore a decrease in the frontomaxillary facial angle.

METHODS

The frontomaxillary facial angle was measured in stored images from 20 fetuses with open spina bifida and 100 normal controls examined between March 2007 and March 2010. The cases and controls were obtained from centers providing routine first-trimester screening for chromosomal abnormalities by measurement of fetal nuchal translucency (NT) thickness[8]. The databases of the hospitals were searched to identify cases of open spina bifida diagnosed during the first or second trimester of pregnancy that had stored images of the mid-sagittal view of the fetal face at 11 + 0 to 13 + 6 weeks' gestation. This view is defined by the presence of the echogenic tip of the nose and rectangular shape of the palate anteriorly, the translucent diencephalon in the center and the nuchal

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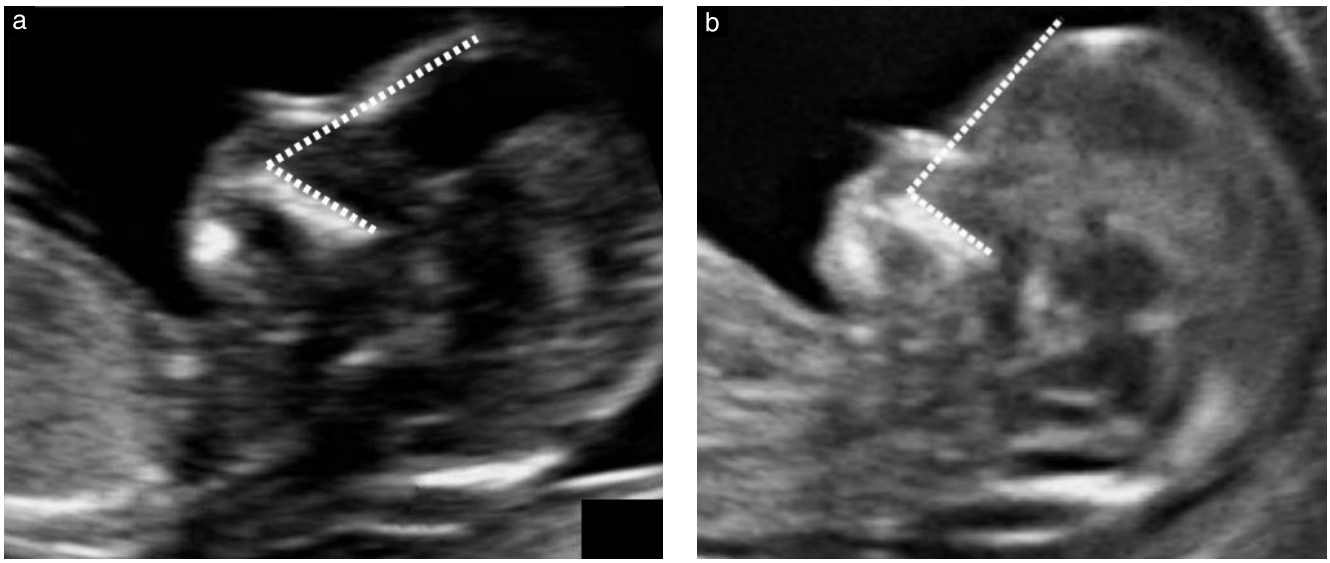

Figure 1 Frontomaxillary facial angle in a fetus with open spina bifida (a) and a normal control (b) at 13 weeks' gestation. The angle was measured between a line along the upper surface of the palate and a line that traverses the upper corner of the anterior aspect of the maxilla extending to the external surface of the forehead (dotted lines).

membrane posteriorly[9]. Deviations from the exact midline plane result in non-visualization of the tip of the nose and visibility of the zygomatic process of the maxilla. For each case of open spina bifida we selected at random five controls with the same CRL at the 11–13-week scan that subsequently resulted in the live birth of healthy neonates.

The stored images of the mid-sagittal view of the fetal face at 11 + 0 to 13 + 6 weeks of the cases of spina bifida and controls were placed in the same folder and were examined by a sonographer with extensive experience in first-trimester scanning who had obtained the Certificate of Competence for measurement of NT and frontomaxillary facial angle of The Fetal Medicine Foundation. This sonographer was unaware of the outcome of the pregnancies, and measured the frontomaxillary facial angle using the Software IQ-View 2.60 (Image Information Systems, Rostock, Germany). The frontomaxillary facial angle was measured between a line along the upper surface of the palate and a line that traverses the upper corner of the anterior aspect of the maxilla, extending to the external surface of the forehead, represented by the frontal bones or an echogenic line under the skin below the metopic suture, which remains open at this gestational age (Figure 1)[1].

Statistical analysis

The measured frontomaxillary facial angle in each fetus in both the spina bifida and control groups was subtracted from the normal mean for CRL in our previously reported reference range (frontomaxillary facial angle in degrees = 93.34 − (0.2 × CRL)) to calculate the delta value[2]. The Kolmogorov–Smirnov test demonstrated that the distribution of delta values did not deviate from normality in both the spina bifida and control groups ($P = 0.884$ and $P = 0.949$, respectively) and the unpaired *t*-test was used to determine the significance of differences in the mean delta-values between the groups. The statistical software package SPSS 15.0 (SPSS, Chicago, IL, USA) was used for data analysis.

RESULTS

In the 20 cases of open spina bifida the median CRL at the time of the first-trimester scan was 62 (range, 48–83) mm and the diagnosis of the condition was made at 22 (range, 13–23) weeks (Table 1). In all cases the parents chose to terminate the pregnancy. The spina bifida was thoracic in three, lumbar in four, lumbosacral in 10 and sacral in three.

The individual measurements of the frontomaxillary facial angle in the spina bifida and control groups plotted on the reference range for CRL are shown in Figure 2[2]. In the control group the frontomaxillary facial angle decreased significantly with CRL ($r^2 = 0.225$, $P < 0.0001$) and the mean delta value was −0.15 with an SD of 3.26.

The mean delta value in the spina bifida group was significantly lower (mean, −9.94; SD, 2.99) than in the control fetuses ($P < 0.0001$; Figure 3). The frontomaxillary facial angle was below the 5th centile of the reference range in 18 (90%) of the cases of spina bifida. The angle was above the 5th centile in one case with a thoracic and one with lumbar lesions. An abnormal appearance of the fourth ventricle and/or cisterna magna was present in all 20 cases of spina bifida.

DISCUSSION

The findings of this study demonstrate that in fetuses with open spina bifida at 11 + 0 to 13 + 6 weeks' gestation the frontomaxillary facial angle is decreased. This is presumably the consequence of caudal displacement of

Table 1 Fetal crown–rump length (CRL), gestational age (GA) at diagnosis and site of spina bifida

Case	*CRL (mm)*	*GA at diagnosis (weeks)*	*Site of spina bifida*
1	79	13	Thoracic
2	61	22	Thoracic
3	56	22	Thoracic
4	71	16	Lumbar
5	82	21	Lumbar
6	62	22	Lumbar
7	61	23	Lumbar
8	48	13	Lumbosacral
9	51	13	Lumbosacral
10	74	13	Lumbosacral
11	62	21	Lumbosacral
12	63	22	Lumbosacral
13	61	22	Lumbosacral
14	83	22	Lumbosacral
15	69	22	Lumbosacral
16	69	22	Lumbosacral
17	61	23	Lumbosacral
18	65	21	Sacral
19	60	23	Sacral
20	62	23	Sacral

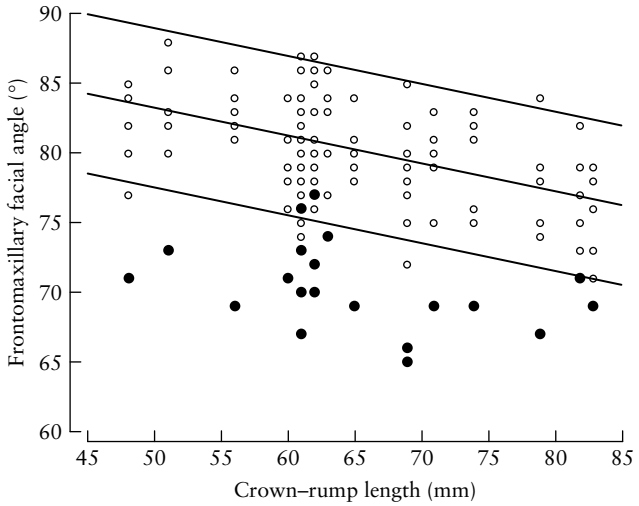

Figure 2 Individual measurements of frontomaxillary facial angle in spina bifida (●) and control (○) groups plotted on the reference range for crown–rump length (median, 5th and 95th centiles).

the fetal brain due to the associated Arnold–Chiari malformation resulting in impaired development of the frontal bones. This is also thought to be the underlying mechanism for the characteristic scalloping of the frontal bones, producing the 'lemon sign' that is usually found in association with open spina bifida during the second trimester of pregnancy[4].

Examination of the mid-sagittal view of the fetal face is performed routinely for assessment of fetal NT and nasal bone in screening for aneuploidies. In this same view the frontomaxillary facial angle can be measured to improve the performance of screening for aneuploidies and, as demonstrated in this study, to screen for open spina bifida. A decreased frontomaxillary facial angle should alert the

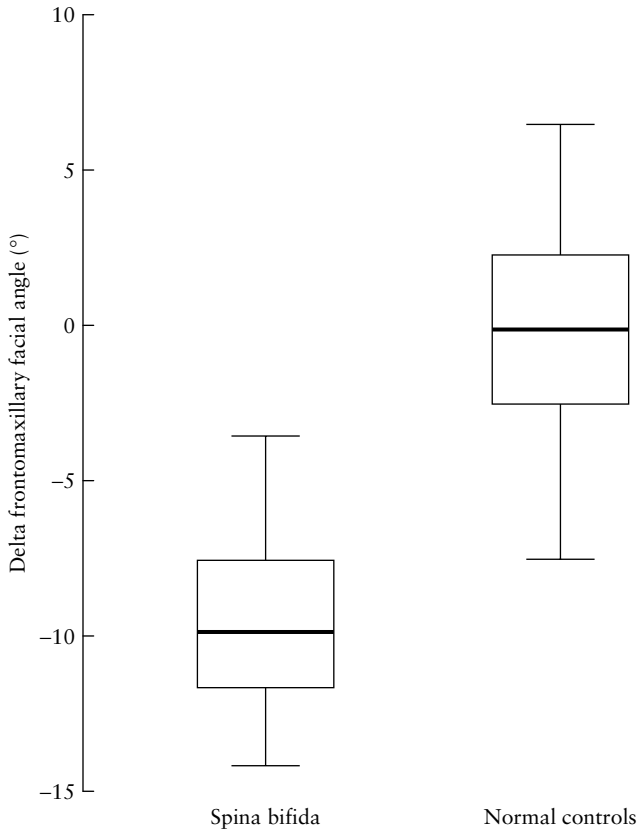

Figure 3 Delta frontomaxillary facial angle in fetuses with open spina bifida and normal controls. Boxes show median and upper and lower quartiles and whiskers show range.

sonographer to the possibility of open spina bifida and encourage a detailed examination of the fetal spine. Such a detailed examination should identify an open spina bifida in the first trimester, but if the views of the spine are inadequate another scan should be carried out in 2–3 weeks.

A limitation of this study is that although the sonographer performing the measurements of the frontomaxillary facial angle was unaware of the outcome of the pregnancies, the suspicion of spina bifida would have been raised by the presence of an abnormal appearance of the fourth ventricle and/or cisterna magna, which could have introduced bias into the measurements. Indeed, because of the coincidence of abnormalities in the posterior brain and decreased facial angle in our fetuses with open spina bifida and because both markers are detectable in the same mid-sagittal view it is not possible to determine whether in future screening they will have a complementary role or not.

In the early 1980s, the main method of screening for open spina bifida was by maternal serum α-fetoprotein at around 16 weeks' gestation. Subsequently, the observation that open spina bifida is associated with caudal displacement of the brain resulting in the 'lemon' and 'banana' signs, shifted screening for this condition from maternal serum biochemistry to second-trimester ultrasonography. It may now be possible to screen for open spina bifida by first-trimester ultrasonography. However, the potential of the frontomaxillary facial angle,

as well as that of intracranial translucency, in early screening for open spina bifida will ultimately be determined by large prospective studies.

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