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ORIGINAL ARTICLE

Two Dimensional Visualization of Optic Chiasma in Fetus

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Abstract The purpose of this study is to investigate methods to visualize and measure the fetal optic chiasma (OC) using transabdominal and/or transvaginal two-dimensional (2D) ultrasound in the coronal plane. The role of analyzing optic chiasma cannot be down scaled in prognosticating septo-optic dysplasia (SOD) and agenesis of septum pellucidum. This is a retrospective study of 117 random cases referred for various indications. The gestational age of the fetuses included in the study was between 19 and 37 weeks. The OC was visualized and measured in the 2D coronal plane with color Doppler by transabdominal and/or transvaginal routes. There were 97 normal low risk cases and 19 abnormal cases in the study. We conclude that it is possible to locate and measure OC width by transabdominal and transvaginal scans from 19 week onwards. It is possible to get equally good views by both, transabdominal and transvaginal routes.

Keywords Optic chiasma (OC) · Two dimension (2D) · Three dimension (3D) · Septo optic dysplasia (SOD) · Agenesis of corpus callosum (ACC) · Partial agenesis of corpus callosum (PACC) · Central nervous system (CNS) · Intra uterine growth restriction (IUGR) · Gestational age (GA) · Magnetic resonance imaging (MRI) · Septum pellucidum (SP)

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Introduction

The Optic Chiasma is an "X" shaped space located in the forebrain, directly in front of the hypothalamus. It is a midline structure where the medial fibers of the optic nerves decussate to continue posteriorly as the optic tracts. It lies in the chiasmatic cistern and along with the pituitary stalk, is completely encircled by the circle of Willis. The decussation is located between the two vertically coursing carotid arteries [1].

Absence of the septum pellucidum and septo-optic dysplasia are considered rare congenital brain malformations which can be difficult to diagnose and even more difficult to prognosticate [2]. However, in recent years, the detection rate of these conditions have been on the rise due to the advancement in prenatal and neonatal diagnostic techniques. Counselling these cases is a challenge in the field of fetal medicine, since it can be an isolated finding or associated with a wide range of brain defects [3].

To date, only a handful of prenatal studies have been conducted evaluating the optic chiasma by using 3D ultrasound [4]. This study aimed at visualizing and measuring the optic chiasma using 2D ultrasound in coronal plane and documenting its measurement at the corresponding gestational age.

Table 1 (a) The lowest (3rd centile) and highest (97th centile) measurements for optic chiasma width at 19 weeks to 34 weeks in our study. (b) The mean length of optic chiasma

(a)

GA (weeks)	n	3rd Centile	5th Centile	50th Centile	95th Centile	97th Centile
19	4	4.39	4.46	5.45	5.84	5.86
20	4	5.1	5.1	5.35	6.02	6.05
21	9	5.6	5.6	6.8	7.86	7.87
22	17	5.44	5.6	6.3	7.88	8.48
23	10	5.31	5.46	6.4	6.75	6.77
24	9	5.74	5.84	6.9	7.86	7.95
25	6	5.39	5.45	6.35	6.77	6.78
26	9	5.89	5.96	6.8	7.38	7.42
27	7	6.13	6.16	6.7	7.31	7.34
28	9	6.12	6.14	7.1	7.98	8.02
29	8	6.04	6.07	6.7	8.49	8.57
30	2	6.10	6.17	7.7	9.23	9.29
31	3	7.20	7.21	7.3	7.48	7.48
32	3	6.03	6.12	8.1	8.28	8.28
33	3	7.1	7.1	7.1	7.37	7.38
34	2	6.11	6.13	6.4	6.67	6.68

(b)

GA (weeks)	*n*	Mean	SD
19	4	5.27	0.68
20	4	5.47	0.47
21	9	6.76	0.89
22	17	6.40	0.92
23	10	6.28	0.52
24	9	6.83	0.74
25	6	6.23	0.56
26	9	6.72	0.52
27	7	6.68	0.47
28	9	7.0	0.69
29	8	7.11	1.01
30	2	7.7	2.4
31	3	7.3	0.15
32	3	7.43	1.33
33	3	7.2	0.17
34	2	6.4	0.42

Materials and Methods

This is a retrospective study of 117 random cases referred to our centre for various indications. The gestational age of the fetuses was between 19 and 37 weeks.

All the cases were screened by a single fetal medicine expert (FMF certified) using Voluson E10, BT 17 ultrasound machine equipped with RAB6-D and RIC6-12-D vaginal probe.

The OC was visualized in the coronal plane by transabdominal and/or transvaginal route. The OC was measured at the level of 3rd ventricle and was seen as a horizontally placed dumbbell-shaped structure of moderate echogenicity. Color Doppler was used in all the cases to clearly demarcate optic chiasma within the arterial box formed by supra cavernous segment of internal carotid artery and anterior cerebral artery.

The GA was rounded up to the nearest week with fractions of ≤ 4 days assigned to earlier week and ≥ 5 days to the later week [10]. The data was then stratified according to gestational age from 19 to 37 weeks.

The data was segregated according to normal low risk cases and abnormal cases like IUGR, macrosomia, Structural anomalies (CNS and extra CNS) and other high risk factors.

There were total 97 normal low risk cases and 19 abnormal cases in this study.

Table 2 The width of OC in abnormal cases

Abnormality	No. of pts 19	GA (weeks)	OC width (mm)
IUGR	1	23	4.5
Macrosomia	1	26	7.3
CNS anomalies	8		
BPC	1	27	7.4
CVI cyst	1	29	6.0
PACC	3	20, 23*, 32**	6.1, 5.2*, 8.1**
SOD	1, 1*	25, 22*	5.8, 5.4*
Bilanophthalmos	1	20	6.7
Hypoplastic cerebellum	1	24	4.0

* and ** symbolise grouping of values in different columns. For eg. OC width of the case of PACC measured at 23 weeks was 5.2 mm (all marked with *) and at 32 weeks was 8.1 mm (both marked with **) and the width of OC of 1 case of SOD at 22 weeks was 5.4 mm (all marked with *)

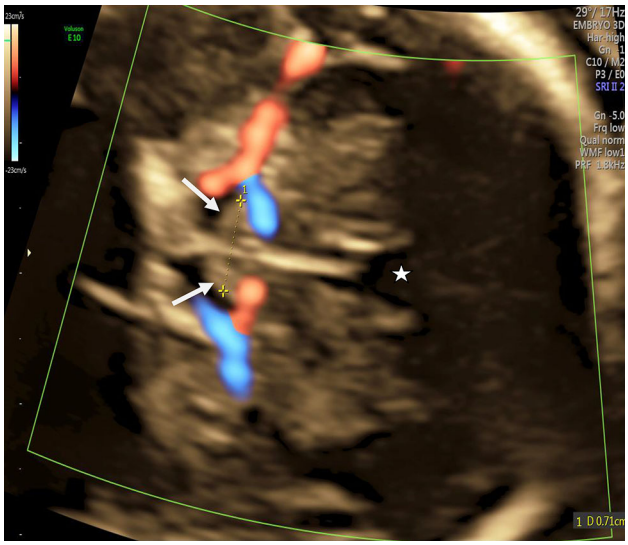


Fig. 1 Transabdominal neurosonographic image in a normal 24-week fetus. Coronal view through anterior fontanelle showing opticchiasm (arrows) and cavum septi pellucidi (*) and measurement of optic chiasma width

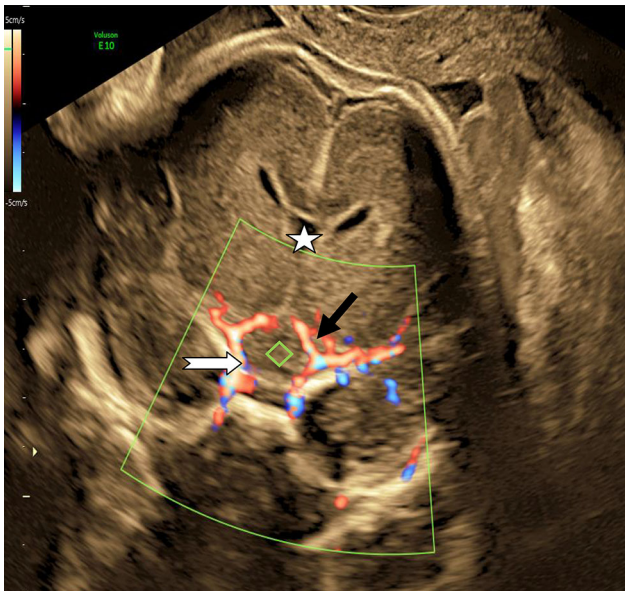
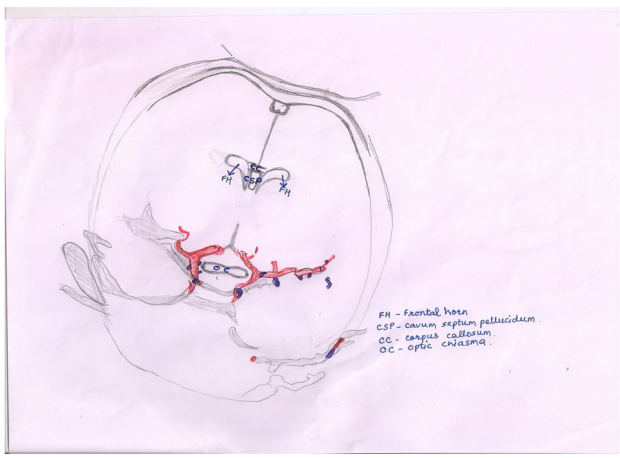


Fig. 2 Transvaginal neurosonographic image in a normal 22-week fetus. Coronal view through anterior fontanelle showing optic chiasm (◇) and cavum septi pellucidi (☆) delimited laterally by the leaves of the septum pellucidum. Same view shows supracavernous segment of internal carotid artery (⇨) and anterio cerebral artery(⬅)

Amongst the abnormal cases, there were 8 cases of CNS anomalies including 2 cases of SOD, one case of bilateral anophthalmia with agenesis of Corpus Callosum (ACC), 3 cases of Partial ACC, 1 case of hypoplastic cerebellum where OC was measured.

Method of visualization: OC was identified through the anterior fontanelle in the coronal view as a dumbbell shaped structure of moderate echogenicity located in the midline at the level of 3rd ventricle. Color Doppler was put at the level of pulsations of circle of Willis. The arterial box formed by supra cavernous segment of internal carotid artery and anterior cerebral artery was visualized. Optic chiasma was located within this arterial box as echogenic dumbbell shaped linear structure and was measured by placing the calipers touching the inner edges of this chiasma walls. 2–3 readings of measurement were taken and the average reading was noted.



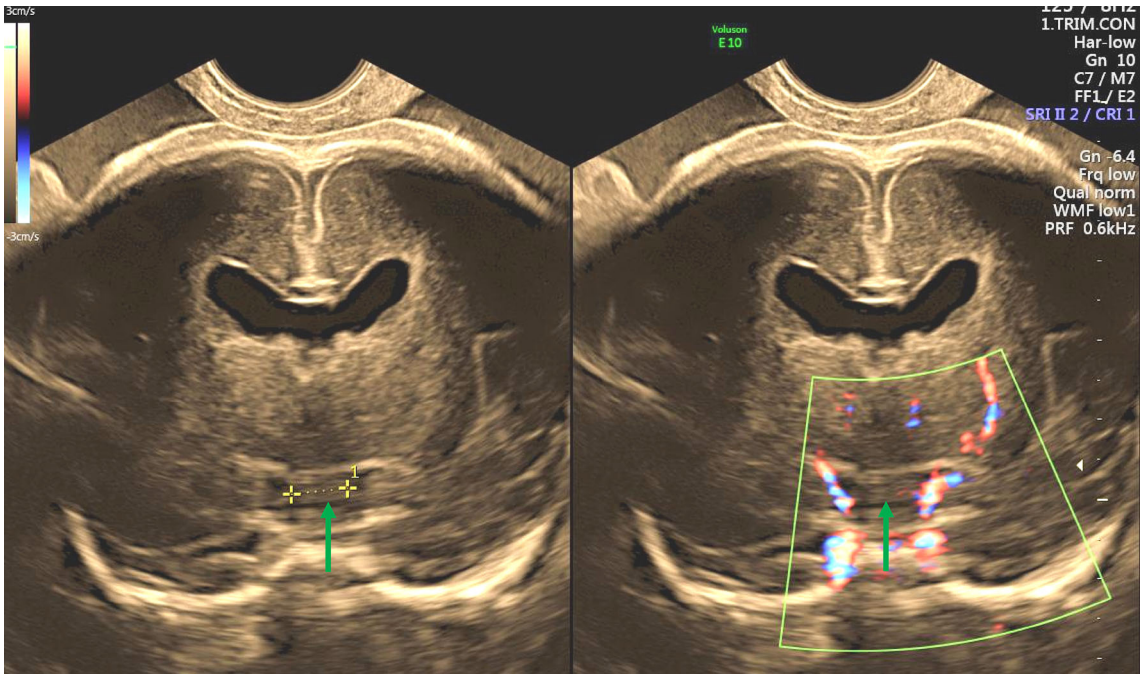
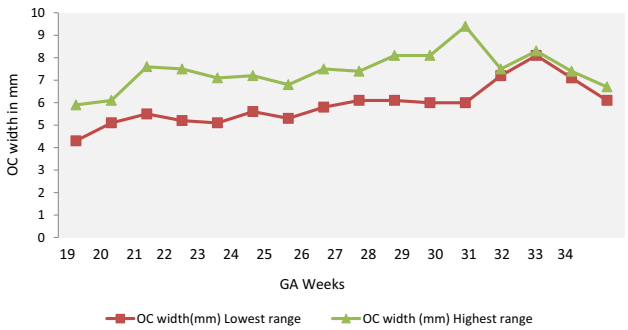


Fig. 3 Optic chiasm (arrow) on TVS two-dimensional ultrasound in a 25-week fetus with Septo-Optic Dysplasia

Results

It was possible to locate and measure OC width by transabdominal and transvaginal route from 19 weeks onwards (Tables 1, 2).

Graph shows OC width increased linearly with gestational age.



Discussion

Embryologically, development of the optic chiasma begins between the fourth and the sixth weeks of gestation. The OC is a decussation formed anteriorly by the converging optic nerves and posteriorly by the diverging optic tracts [1].

The OC is an important landmark for interpreting sonographic examinations. Despite being such a small structure, the chiasma aids in prognosticating the diagnosis of SOD and agenesis of septum pellucidum. Hypoplasia of the optic nerves may be difficult to assess even with MRI [5]. In the presence of hypoplastic optic chiasma, the suspected diagnosis of SOD should be confirmed by the presence of maternal and fetal endocrinologic deficiencies. Pituitary dysfunction when present, represents a typical sign of SOD [6, 7] (Figures 1, 2, 3, 4 and 5).

This study demonstrates that visualization of OC is possible using 2D—TAS/TVS ultrasound and comparing its width with normal range builds the confidence of the

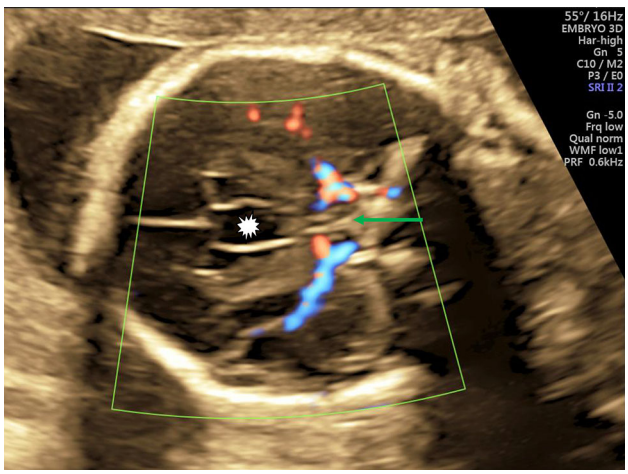


Fig. 4 Small abnormally shaped optic chiasm (arrow), cavum septum pellucidum (✲) on TAS two-dimensional ultrasound in a 24-week fetus with hypoplastic cerebellum

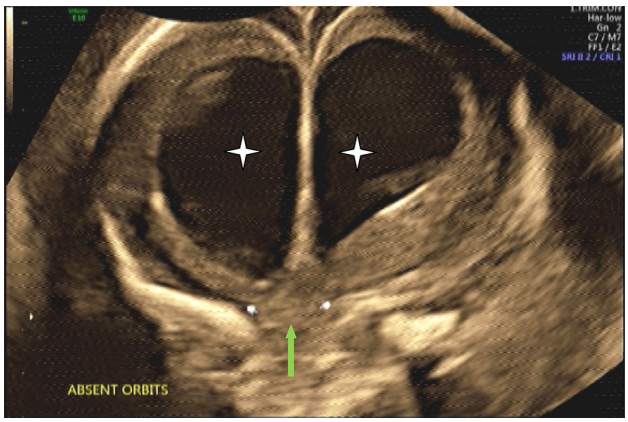


Fig. 5 Optic chiasm (arrow) and dilated frontal horns of lateral ventricle (✧) on TVS two-dimensional ultrasound in a 21-week fetus with bilateral anophthalmia

operator in detecting and counseling abnormal cases, like SOD and agenesis of SP. Abnormally small optic chiasma in SOD carries a poor prognosis [8, 9].

Good views of OC in breech presentation could be obtained by transabdominal route, and in cephalic presentation by transvaginal route.

The measurements of OC obtained in the present study are in concordance with the observation of Vinals et al. [10].

We did not stress on abnormal cases as the primary purpose was to show that it is possible to accurately measure fetal OC on 2D ultrasound. The second objective was to obtain the referral values of OC at various gestational ages. To our knowledge, this is the only study which gives the lowest (19 weeks) and the highest (37 weeks) readings of optic chiasma measurement. Another novel feature of this study is the visualization of OC by both transabdominal and/or transvaginal route. Color Doppler was used in all the cases to accurately locate and measure OC.

The main limitation of the present study is that the inter-observer reproducibility of the findings was not done. Secondly, the number of cases in higher gestational age was less. Thirdly, the number of abnormal cases were few. And lastly, the confirmation of abnormal cases by antenatal or postnatal MRI or autopsy was not done.

Conclusion

This study demonstrates that it is possible to visualize and measure the fetal OC in 2D coronal plane by ultrasound. Expertise in visualizing OC in normal fetuses gives the operator the confidence in reporting the status of OC in abnormal cases and counseling the complicated cases like SOD and agenesis of septum pellucidum.

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