Original Article

Assessment of Placental and Umbilical Cord Morphology with Analysis of Umbilical Coiling Index: A Cross-Sectional Study

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Abstract

Background: Every year 30 million infants suffer from Intrauterine Growth Retardation (IUGR). The mean IUGR rate in India is 54%. The prevalence of low birth weight in India is 26%. Placenta is the vital foeto-maternal unit responsible for the maintenance of pregnancy, foetal growth and development. Furthermore, the umbilical cord serves a paramount role in foetal intrauterine persistence. Assessment of umbilical cord and placental dimensions thus determine the foetal outcome. In addition, the umbilical coiling index has an impact on perinatal outcomes. **Material and Methods:** A cross-sectional investigation was conducted on 37 specimens of placenta with umbilical cords obtained from Department of Obstetrics and Gynecology, Akash Institute of Medical Sciences and Research Centre, Bengaluru. Placental form, diameter, placental cotyledons and mechanism of attachment of umbilical cord were observed. The length and diameter of umbilical cord, umbilical coiling index (UCI) were measured and statistical analysis was performed. **Results:** Mean diameter of placenta, diameter and length of umbilical cord, average number of placental cotyledons were analyzed using SPSS 20. Percentage was calculated for shape of the placenta and mode of attachment of the umbilical cord to the placenta. UCI was calculated using the formula and UCI of <10th percentile was classified as hypo coiled and UCI of >90th percentile as hyper coiled. **Conclusion:** An extensive understanding of the placenta and umbilical cord, along with their clinical significance, is valuable for the early assessment of fetal well-being.

Keywords: Umbilical cord, placenta, umbilical coiling index, Intrauterine Growth Retardation, cotyledons.

Received: 20 May 2026 **Revised: 05 June 2026** **Accepted: 22 June 2026** **Published: 08 September 2026**

Introduction

The placenta is a highly vascular, disc-like structure through which the fetus is attached to its maternal uterine wall. It has a maternal part derived from the endometrium of the uterus (decidua basalis) and a fetal part derived from the chorion. The placenta facilitates the exchange of gases, nutrients, and metabolic waste products between mother and fetus. The maternal surface is divided into 15-20 lobes known as "cotyledons", which are separated by deep groove, giving it cobblestone appearance. Cotyledons are the perfusion chambers into which the maternal spiral arteries discharge blood. The fetal surface is covered by the amnion, shiny and smooth in appearance.[1]

Renowned comparative paleontologist Harland Mossman briefly summarized placenta as "the typical mammalian placenta is an apposition of the foetal membrane to the uterine mucosa for physiological exchange".[2] The placenta is a predictor of pregnancy difficulties and a sign of the health status of the mother and foetus. The normal weight of placenta is about 500 g with a diameter of 15-20 cm and a thickness of 3cm.[3] Morphological defects of the placenta interfere with the normal development of the foetus as shown in gestational diabetes, hypertension and elderly primigravida.[4] Most placentas are oval or circular in form. Variations in the shape are usually associated with altered placental function in utero.[4] Hence, the postpartum examination of the placenta reflects the normal fetal development, and in case of fetal death, it serves as important medico-legal evidence. Placental growth in the antenatal period, detected by ultrasonography, mirrors the fetal growth and neonatal outcome.[5]

The umbilical cord is the connecting link between the placenta and the fetus, through which the developing fetus receives nutrition, immune support, removal of waste products and gaseous exchange.[6] The umbilical cord is dull white in appearance, 50-60 cm in length and 1-2cm in diameter.[7] Short cord is defined as cord length of less than 32 cm and long cord as cord length of more than 100cm.[8]

The umbilical cord has two umbilical arteries and one umbilical vein. These are embedded in mucoid connective tissue (Wharton's jelly) and are covered by a glossy amniotic membrane. The deoxygenated blood from the fetus reaches the

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DOI:
10.21276/amit.2026.v13.i3.1016

How to cite this article: Jain A, Varalakshmi KL, Kulkarni V. Assessment of Placental and Umbilical Cord Morphology with Analysis of Umbilical Coiling Index: A Cross-Sectional Study. Acta Med Int. 2026;13(3):44-48.

placenta for oxygenation through umbilical arteries, and after oxygenation, the purified blood returns to the fetus via the umbilical vein.[9] The umbilical cord is normally attached to the center of the placenta (central type); in some cases, it may be paracentral, marginal or membranous in position. Location of cord insertion is also important as abnormal site of insertion affects the normal development and function of the placenta and adversely affects the fetal growth and birth weight.[10] Along the course of the umbilical cord, there are around 11 vascular coils. Normal umbilical cord shows one coil for every 5cm. Umbilical coiling index index (UCI) is calculated by dividing the total number of coils by the total length of the cord in centimeters. These coils strengthen the cord and are considered indicators of fetal well-being. It maintains the vascular flow by protecting the umbilical cord from external compression by providing elasticity to the cord.[11] Rana et al performed the frequency distribution of UCI and divided them into hypercoiled (>90th percentile), hypocoiled (<10th percentile) and normocoiled (10th -90th percentile).[12]

Considering the functional and clinical importance of the placenta, the present study was undertaken with an objective to explore the morphological differences of placenta and umbilical cord and to find out the factors related with these variations in a tertiary care institution in South India. The study findings will also be correlated with existing literature.

Materials and Methods

A cross-sectional examination was undertaken on 37 specimens of placenta with umbilical cords acquired from the Department of Obstetrics and Gynaecology, Akash Institute of Medical Sciences and Research Centre, Bengaluru, over a period of two months. Ethical clearance was obtained from the Institutional Ethics Committee. Written informed consent was obtained from the parents in their local language.

Immediately after delivery (full-term normal vaginal delivery and emergency LSCS), the placenta and umbilical cord were collected, properly cleaned under running water, tagged, and preserved in 10% formalin.

Inclusion Criteria

All intact, normal full-term placentas from singleton pregnancies obtained after normal vaginal delivery and caesarean section were included in the study.

Exclusion Criteria

Placentae that were damaged or macerated, and those obtained from complicated pregnancies (such as hypertension, diabetes mellitus, anaemia, HIV infection, hepatitis B infection), multiple pregnancies, and preterm pregnancies were excluded from the study.

The following placental parameters were evaluated:

- Shape of the placenta
- Number of cotyledons
- Placental diameter
- Mode of attachment of the umbilical cord to the placenta
- Presence of any placental abnormalities

The umbilical cord specimens were examined carefully for the following parameters:

- Length of umbilical cord
- Diameter of umbilical cord
- Umbilical cord coiling pattern
- Presence of knots

Neonatal details, including birth weight, sex, and mode of delivery, were recorded. A measuring tape was used to measure the length of the umbilical cord and diameter of the placenta. Diameter of umbilical cord was measured using a digital vernier caliper.

Statistical Analysis: All data were tabulated, and statistical analysis was performed using IBM SPSS Statistics version 20.

Mean and standard deviation were calculated for continuous variables, including the length of the umbilical cord and the diameter of the placenta and umbilical cord. Frequency distribution was performed for the number of cotyledons.

Percentages were calculated for categorical variables, including the shape of the placenta and mode of attachment of the umbilical cord to the placenta.

The umbilical coiling index (UCI) was calculated, and the specimens were classified as normocoiled, hypocoiled, or hypercoiled based on the obtained values.

Results

A total of 37 placentae with umbilical cords were included in the present study. The following parameters were evaluated.

1. Shape of Placenta: Various shapes of placentae were observed in the present study. The oval shape was the predominant type observed.

Table 1: Distribution of various shapes of placenta

SI No	Shape	Number	Percentage
1	Oval	14	37.83
2.	Irregular	7	18.91
3.	Discoid	10	27.02
4.	Triangular	4	10.81
5.	Cone	1	2.70
6.	Heart shaped	1	2.70

Table 2: Frequency distribution of number of cotyledons

Range of cotyledons	Number of placentae
0-5	4
6-10	11
11-15	13
16-20	5
21-25	4

Figure 1: Distribution of various shapes of placenta (A-oval, B-disc, C-Irregular, D-triangular, E-cone, F-heart shaped)

Mode of attachment of the umbilical cord to the placenta
There are four different forms of umbilical cord attachment to the placenta.[13]
Central: The placenta's center is where the umbilical cord is attached.
Paracentral: The umbilical cord is implanted two centimetres from the placenta's edge.
Marginal/Battledore: The umbilical cord is attached to the edge or within two centimetres of it.
Membranous /velamentous: in this type of umbilical vessels are inserted into Chori amniotic membrane.
In the present study paracentral type was predominant followed by marginal. Velamentous type was absent

Table 3: Distribution of mode of attachment of umbilical cord to placenta

SI no	Type of attachment	Number	Percentage
1.	Central	4	10.81
2.	Paracentral	26	70.27
3.	Marginal	7	18.91

Table 3: Morphometric measurement of placenta and umbilical cord

Parameters	Mean	Standard deviation
Placental diameter (in cm)	17.47	2.28
Length of umbilical cord (in cm)	52.87	13.49
Umbilical cord diameter (in mm)-placental end	11.42	3.65
Umbilical cord diameter (in mm)-fetal end	11.51	3.04
Number of coils in umbilical cord	12.86	6.85

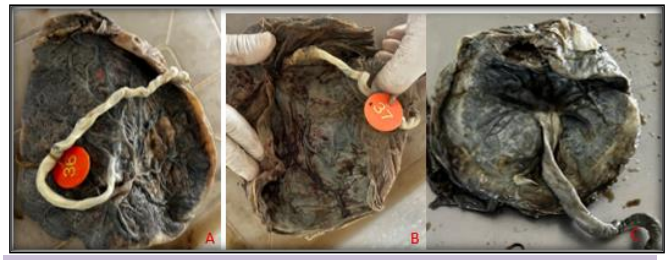

Figure 2: Mode of attachment of umbilical cord to placenta (A-Paracentral, B-Marginal, C-Central)

Umbilical coiling index (UCI): The following formula was used to determine the umbilical coiling index:
UCI is equal to the number of coils in the umbilical cord divided by its overall length.
The mean UCI was 0.492 with standard deviation of 0.213.
The 10th percentile of UCI is :0.251 and 90th percentile is 0.830
Hence UCI of <0.251 is hypo coiled and >0.83 is hyper coiled umbilical cord.
Below 0.2511(hypocoiled): -4 specimens-10.8%
Between 0.251-0.830(Normocoiled):30 specimens-81.08%
Above 0.830(hypercoiled):3 specimens-8.10%.

Discussion

The morphological variations in the shape of the placenta are key indicators of its developmental pattern and functional efficacy. The location and mode of implantation in the uterus, as well as differences in the mother's vascular supply, all affect the placenta's shape. Studies have shown that irregular placental shapes may occur due to fetoplacental or maternal uteroplacental vascular pathology, which can affect not only the morphology but also the functional efficacy of the placenta. These variations are also associated with intrauterine growth restriction, low birth weight, and prematurity. Recent studies suggest that the shape of the placenta is determined by the persistent area of chorionic villi. During early pregnancy, the placenta contains approximately 800–1000 stem villi, which later regress to about 60 stem villi in the mature placenta.[14]
The normal full-term placenta is a discoid mass that is usually oval or round in shape.[15] Apart from the normal round or oval shape, placentae may also exhibit triangular, irregular, conical, heart-shaped, and bilobed configurations. In the present study, the oval shape was predominant, and these findings correlated with the observations of Sabahat Gul et al.[16]
The placental diameter reflects the intrauterine environment and the functional efficiency of the placenta. The normal diameter of the placenta ranges from 15 to 20 cm. Kishwara et al. compared normal and hypertensive placentae and concluded that the diameter of preeclamptic placentae was smaller compared to normal placentae.[17] The reduction in placental diameter in preeclampsia may be attributed to vasospasm and reduced uterine perfusion.[18] Conversely, an increased placental diameter has been observed in gestational diabetes mellitus and anaemia, which may represent a compensatory mechanism to meet the increased nutritional demands of the fetus. Variations in placental diameter further support the concept of morphological diversity of the placenta.[19]
Cotyledons are considered the functional units of the placenta, and their number is highly variable, reaching a maximum in the term placenta. Individual cotyledons are covered by trophoblastic tissue and separated from adjacent cotyledons by connective tissue grooves. Maternal spiral arteries supply blood to the

cotyledons.[20] Sadler mentioned that the average number of cotyledons in a human term placenta range from 15 to 20.[21] A study by Vijayalakshmi et al. reported that the average number of cotyledons was 18 and concluded that a reduction in the number of cotyledons was observed in preeclamptic placentae and premature births.[22] In the present study, 13 placentae showed 11–15 cotyledons.

The placenta's umbilical cord attachment was the subject of a study by Raghunath G. According to the study, 16.36% of insertions were marginal, 7.27% were furcate, and 0.90% were velamentous, whereas 75.45% of insertions were central or eccentric, which were deemed typical. Paracentral was the most common kind in this investigation, followed by marginal.[23]

Long umbilical cords (>100 cm) were associated with an increased incidence of birth asphyxia, cord entanglement, and cord prolapse, whereas short cords (<25 cm) were associated with placental abruption. According to Peter AK's analysis of 265 umbilical cords, the average length was 44.8 cm, with a 12.0 cm standard variation.[24]The average umbilical cord length, according to another study by Gupta S et al., was 44.3 cm, with a standard deviation of 9.2 cm. The umbilical cord has a distinctive spiral coiling pattern and is normally 40 to 60 cm long. The cord is made stronger and more flexible by this coiling. Foetal death, intrauterine growth limitation, chorionic vascular thrombosis, umbilical vein thrombosis, and cord stenosis are all linked to excessive coiling.[25] In the present study, the mean length of the umbilical cord was 52.87 ± 13.49 cm, which was within the normal range.

The number of complete vascular coils divided by the umbilical cord's total length in centimetres yields the umbilical cord coiling index (UCI). Edmonds was the first to describe umbilical cord coiling, commonly referred to as the "index of twist."[11] De Laat et al. studied the postnatal umbilical cord coiling index (pUCI) in 565 samples and found that hypo coiling was related to intrauterine death (IUD), fetal anomaly with a low Apgar score at 5 minutes. Hyper coiling was related to IUD, preterm birth (PTB), fetal anomaly, fetal thrombotic vasculopathy (FTV), and hypoxia with low birth weight (BW).[26]

Machin et al. (2000) studied the postnatal umbilical cord coiling index (pUCI) in 1329 samples and found that hypo coiling was related to IUD, fetal distress with low birth weight. Hyper coiling was related to IUD, fetal distress with low birth weight, and FTV.[27] Abnormal umbilical coiling index (hypocoiled/hypercoiled UCI) has been linked to poor perinatal outcomes and increased NICU admission rates, according to a number of studies.[28]

Conclusion

Placental and umbilical cord morphometry gives us reflection of the antenatal events. Hypo coiled cords were associated with foetal distress and low birth weight whereas hyper coiled cords were associated with thrombosis of chorionic vessels and intrauterine growth retardation. The present study contributes to the platter of baseline data of placenta and umbilical cord morphometry to anatomists, sonologists, pathologists and gynaecologists.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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