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SHORT REPORT

# Maternal–fetal attachment in blind women using physical model from three-dimensional ultrasound and magnetic resonance scan data: six serious cases

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**Abstract**

*Objective*: The objective of this study is to assess the maternal–fetal attachment (MFA) in six blind pregnant women by means three-dimensional (3D) physical models from 3D ultrasound and magnetic resonance imaging (MRI) scan data.
*Methods*: We performed a prospective observational cross-sectional study with six blind pregnant women who performed 3D ultrasound and MRI exams to build 3D physical models for their fetuses. The MFA was assessed quantitatively by means a questionnaire of three questions, each one with a score ranging from 0 to 3. We considered MFA values $\geq 7$ to each pregnant woman. The descriptive data were expressed by mean ± standard deviation (SD).
*Results*: The mean (±SD) maternal age was 32 ± 2.7 years. The mean gestational age at 3DUS and MRI exams were 23.1 ± 3.7 and 21.3 ± 0.9 weeks, respectively. The mean of gestational age at delivery was 36.5 ± 4.7 weeks and all of them were cesarean sections. The mean newborn weight was 2615.8 ± 871.9 g and the gender was 50% both female and male. The MFA was quantitatively observed in all pregnant women, with maximum value (9) in all of them.
*Conclusion*: The MFA was quantitatively observed in all blind pregnant women using 3D physical models.

**Keywords**

Blind pregnant women, magnetic resonance imaging, maternal–fetal attachment, physical model, three-dimensional ultrasound

**History**

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## Introduction

Maternal–fetal attachment (MFA) is defined as the extension in which women engage in behaviors that represent an affiliation and interaction with their unborn child [1]. The ability to view a fetus as an independent being at an earlier point in pregnancy likely contributes to the MFA developing at a much earlier point in fetal development [2].

The introduction of ultrasound in the clinical obstetrics practice allowed the quantitative assessment of MFA. The two-dimensional ultrasound (2DUS) allows the assessment of MFA by the analysis of extent of prenatal image sharing, maternal ability to form a mental picture of the baby and mother's comments about their ultrasound images [3], as well as reduces the maternal anxiety [4]. The three- and four-dimensional ultrasound (3D/4DUS) in the surface rendering allows the assessment of fetal behaviors during all trimesters of pregnancy [5]; however, comparative studies between 2D- and 3D/4DUS did not show differences in the MFA, despite 3D/4DUS allows better understanding of fetus image [6,7].

Physical models from 3DUS, magnetic resonance imaging (MRI), and computed tomography (CT) scan data allow models remarkably similar to the postnatal appearance of the newborns, both normal and with congenital anomalies. This method can be used as medical education and to the visualization of the baby by their parents [8,9]. These physical models would be very important to the assessment of MFM in blind pregnant women; however, until this moment, there are no studies in the literature about this purpose. The objective of this study was to assess the MFA in six serious cases of blind pregnant women.

## Methods

A prospective observational cross-sectional study was performed with six blind pregnant women whose husbands too were blind. This study was performed between September 2012 and September 2014 with blind pregnant women in the second and third trimesters of pregnancy who were attended in the Clínica de Diagnóstico por Imagem (CPDI), Rio de

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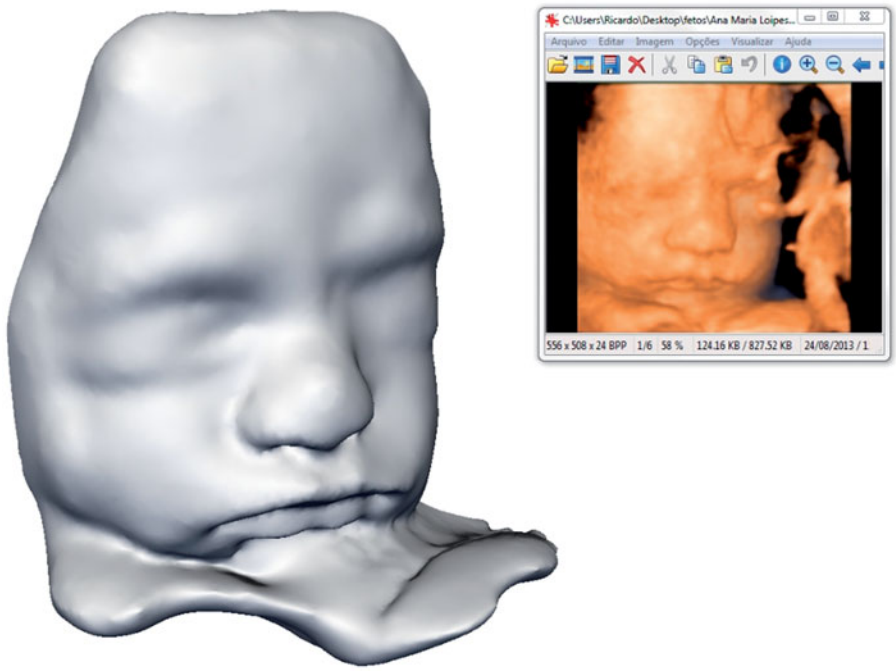

Figure 1. Three-dimensional (3D) ultrasound in the rendering mode of fetal face and their respective 3D physical model at 25 weeks of gestation.



Janeiro, Brazil. The patient women gave the consent form to voluntary participation in this study as well as to publish their images. This study represented the first experience of our group using 3D physical models in blind pregnant women and these patients were selected consecutively from private health services of Rio de Janeiro, Brazil.

The 3DUS and MRI scan were performed by a single examiner (HW). All pregnant women performed the 3DUS and five of them perfomed the MRI exam. All fetuses did not present malformations. Each pregnant women was scanned once time both 3DUS and MRI. The ultrasound examination was performed using a Voluson E8 (General Eletric Medical System, Zipf, Austria) apparatus with a convex volumetric probe (RAB 4–8 L). The MRI was performed using a 1.5-T scanner (Magneton Avanto and Aera; Siemens, Erlangen, Germany). The protocol used was T2-weighted sequence (half-Fourier acquisition single shot turbo spin echo; repetition time shortest, time to echo 140 ms; field of view = 300Y200 mm; matrix 256 _ 256; slice thickness 4 mm, 40 slices, and acquisition time 18 s in three planes of the fetal body). In addition, we applied T2-weighted true fast imaging with steady-state precession (True FISP) sequence in the sagittal plane (repetition time 3.02 ms, time to echo 1.34 ms, voxel size 1.6 _ 1.6 _ 1.6 $mm^3$, fractional anisotropy 70, parallel acquisition techniques 2) with 96–136 slices of thickness 1.0–1.6 mm and an acquisition time of 26 s. The total duration of the examination did not exceed 40 min. Maternal sedation was not necessary [10].

All 3DUS and MRI scan data were exported to a workstation in DICOM format for manual, slice-by-slice segmentation using a digital high definition screen tablet (Cintiq Wacom, Tokyo, Japan) was performed. The virtual segmentation of the internal volume was performed using the software Mimicsv.16; Materialize, Leuven, Belgium. The 3D volume was then exported in an extension STL (Standard Triangular Language), a coordinate data used in all existent additive manufacturing technologies [10] (Figure 1).

The blind pregnant women were followed until their deliveries and all newborns showed normal phenotype. The data were transferred to an Excel spread sheet (Microsoft Corp., Redmond, WA) and the descriptive data (maternal age, gestational age at 3DUS, gestational age at MRI, gestational age at delivery, Apgar scores at the 1st and 5th minutes and weight of newborns) were presented as mean ± standard deviation (SD). The MFA was assessed quantitatively by means a questionnaire of three questions, each one with a score ranging from 0 to 3: ''How do you fell holding your baby?'' (very happy = 3; happy = 2; indifferent = 1; sad = 0); ''Will this physical model improve the interaction with your baby and husband?'' (completely = 3; yes = 2; maybe = 1; no = 0); ''Could you image how the baby will be?'' (completely = 3; yes = 2; maybe = 1; no = 0). The MFA was assessed immediately after the development of 3D physical models and we considered values $\geq 7$ as the presence of MFA. The patients were followed until their deliveries, and we had not assessed their postpartum data including the breast feeding.

## Results

We assessed six blind pregnant women whose husbands were blind too. The mean (±SD) maternal age was 32 ± 2.7 years. The mean gestational age at 3DUS and MRI exams were 23.1 ± 3.7 and 21.3 ± 0.9 weeks, respectively. The mean of gestational age at delivery was 36.5 ± 4.7 weeks and all of them were cesarean section. The mean weight of newborn was 2615.8 ± 871.9 g and the gender was 50% both female and male. The mean Apgar scores at 1st and 5th minutes were 8.1 ± 2.0 and 9.3 ± 1.6, respectively. With the exception one pregnant woman with diabetes mellitus type I and chronic renal disease (Case 6), all other were normal (Table 1).

The MFA was quantitatively observed in all pregnant women, with maximum value (9) in all of them. Figures 2 and 3 show two blind pregnant women (Cases 2 and 3) with their

Table 1. Demographic data of six blind pregnant women.

| Case | Age | Parity | 3DUS* | MRI† | GA‡ | Delivery | Gender | Apgar 1¶ | Apgar 5§ | Weight (g) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 32 | G2-P1 | 16 | 25 | 38 | Cesarean | Female | 9 | 10 | 2900 |
| 2 | 35 | G1-P0 | 22 | 27 | 39 | Cesarean | Male | 9 | 10 | 3050 |
| 3 | 28 | G1-P0 | 26 | 26 | 39 | Cesarean | Female | 9 | 10 | 2900 |
| 4 | 32 | G1-P0 | 25 | 25 | 38 | Cesarean | Male | 9 | 10 | 2900 |
| 5 | 35 | G2 P1 | 25 | 25 | 38 | Cesarean | Male | 9 | 10 | 3100 |
| 6 | 30 | G1-P0 | 25 | –‖ | 27 | Cesarean | Female | 4 | 6 | 845 |

3DUS, three-dimensional ultrasound; MRI, magnetic resonance imaging; GA, gestational age.

*Gestational age at the moment with 3DUS was performed.

†Gestational age at the moment with MRI was performed.

‡Gestational age at delivery.

¶Apgar score at the 1st minute.

§Apgar score at the 5th minute.

‖The pregnant woman did not perform the MRI exam because of claustrophobia.



Figure 2. Blind pregnant woman at 22 weeks of gestation with his husband holding the 3D physical model of their fetus (Case 2).

respective husbands holding the 3D physical models from their fetuses. The mean time to answer the questions was 5.0 min, and only the pregnant women answered them.

## Discussion

Some studies refer that the gestational age at the time of ultrasound exam have influence in the development of MFA. Usually, when start the first fetal movements and the pregnant women perform these movements, the development of MFA tends to be higher [11,12]. It was the reason for us to develop this study in the second and third trimesters of pregnancy, with a mean gestational age of 23.1 weeks.

3DUS allows a realistic vision of fetal face and your behavior [5]. Some studies compared the conventional 2DUS

Figure 3. Blind pregnant woman at 26 weeks of gestation with his husband holding the 3D physical model of their fetus (Case 3).

with 3DUS in the assessment of MFA, but the results were conflicting [3,6,7,12]. Rustico et al. [12] performed a randomized study comparing only 2DUS and 2D- and 4DUS in the assessment of MFA in the second and third trimester. Fifty-two pregnant women were assessed only with 2DUS (Group 1) and 48 who underwent 2D- and 4DUS (Group 2). These authors did not observe statistical differences between both groups regarding the MFA. On one hand, Lapaire et al. [7] performed a randomized study in the second and third trimester comparing 2D- and 3DUS in the assessment of MFA. Sixty pregnant women were assessed and despite the 3DUS may facilitate recognition of the fetus, there were no statistical differences between both groups in the MFA. On the other hand, Ji et al. [3] compared 50 pregnant women who performed 2DUS and 50 who performed 2D- and 3DUS. Pregnant women having a 3DUS exam consistently scored higher than those having a 2DUS exam for all categories of MFA. However, an objective method for assessment of MFA in blind pregnant women is not possible using ultrasound exam.

Three-dimensional physical models have gained great development in the recent years because of the development of high-performance software used in the different areas of engineering, architecture, and design. In the obstetrics area, the creation of 3D models of fetus may be useful providing the MFA [13]. Werner et al. [8] described the use of 3D physical models in maternal fetal area from 3DUS, MRI and

CT scan data both normal and abnormal fetuses. The 3D physical models were remarkably similar to the newborn appearance, especially in malformation cases. The 3D physical models have been applied to the reconstruction of several fetal malformations as Chiari II and cervical teratoma [10,14]. All blind pregnant women delivered by cesarean section. This high rate is in agreement with the high rate of cesarean sections in private health services in Brazil [15].

In this study, we proved the MFA in blind pregnant women with normal fetuses using 3D physical models from 3DUS and MRI scan data. We used a simple questionnaire with only three questions and all six pregnant women obtained maximum note in all these questions. Despite a short serious case, we believe that 3D physical models can be an effective method to assess the MFA in blind pregnant women.

In summary, the MFA was quantitatively observed in all blind pregnant women using 3D physical models. New studies with more number of cases are necessary to prove our results.

## Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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