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CLINICAL ARTICLE

4D ultrasound evaluation of fetal facial expressions during the latter stages of the second trimester

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ABSTRACT

Objective: To assess the frequency of fetal facial expressions at 25–27 weeks of gestation using 4D ultrasound. *Methods:* Twenty-four normal fetuses were examined using 4D ultrasound. The face of each fetus was recorded continuously for 15 minutes. The frequencies of tongue expulsion, yawning, sucking, mouthing, blinking, scowling, and smiling were assessed and compared with those observed at 28–34 weeks of gestation in a previous study. *Results:* Mouthing was the most common facial expression at 25–27 weeks of gestation; the frequency of mouthing was significantly higher than that of the other 6 facial expressions ($P < 0.05$). Yawning was significantly more frequent than the other facial expressions, apart from mouthing ($P < 0.05$). The frequencies of yawning, smiling, tongue expulsion, sucking, and blinking differed significantly between 25–27 and 28–34 weeks ($P < 0.05$). *Conclusion:* The results indicate that facial expressions can be used as an indicator of normal fetal neurologic development from the second to the third trimester. 4D ultrasound may be a valuable tool for assessing fetal neurobehavioral development during gestation.

1. Introduction

Fetal facial expressions are thought to be indicative of normal fetal neurologic development [1–3]. In a previous study in which 4D ultrasound was used to assess fetal facial expressions, it was shown that fetuses display a broad spectrum of facial expressions—as seen during emotional expression by adults; thus, it might be possible to use 4D ultrasound to assess fetal condition [4]. Assessing facial activity using conventional 2D ultrasound is hard because of the complexity of facial anatomy and the limited utility of conventional 2D ultrasound [4].

In a previous investigation, fetal facial expressions were examined at 28–34 weeks of gestation using 4D ultrasound [5]. Mouthing was significantly more common than all of the other facial expressions, and scowling and sucking were the rarest expressions [5]. The aim of the present study was to evaluate the frequencies of fetal facial expressions at 25–27 weeks of gestation using 4D ultrasound in order to assess fetal neurologic developmental levels during gestation.

2. Materials and methods

From September 1, 2010, to March 31, 2011, women who were 25–27 weeks pregnant and scheduled to undergo routine ultrasound examinations were asked to participate in a 15-minute examination of fetal facial expressions. The study was approved by the Ethics Committee of the Kagawa University School of Medicine, Miki, Japan, and standardized informed consent was obtained from each patient.

Women who were carrying more than 1 fetus were excluded. Estimates of gestational age were calculated based on the first day of the last menstrual period. Confirmation of gestational age was obtained via first-trimester or early second-trimester sonographic examinations.

All 4D examinations were performed using a Voluson E8 (GE Medical Systems, Milwaukee, WI, USA) ultrasound system and a 1–4-MHz transabdominal transducer (RAB2-5-D; GE Medical Systems, Milwaukee, WI, USA). After 2D ultrasound examination, the machine was put in 4D mode. During the visualization of fetal facial expressions, the transducer was arranged so that sagittal sections of the fetal face—including the forehead, nose, and mouth—were obtained. The images were taken in the region of interest (ROI). A volume box, the parameters of which had been determined by the examiner, was superimposed over the 2D image, and a corresponding 3D image was then reconstructed. The crystal array of the transducer was automatically passed over the ROI 40 times per second (maximum speed), and the resultant 4D images were shown on a monitor. All examinations lasted 15 minutes and were recorded on video. A quiet, temperature-controlled room was used as the venue for the examinations, which were conducted in the afternoon. No mechanical or acoustic stimulation was used during acquisition of the images.

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As described previously [5], the examiner assessed 7 types of facial expression when viewing the video recordings: blinking (Supplementary Material S1 [fetal blinking at 27 weeks of gestation]); mouthing (Supplementary Material S2 [fetal mouthing at 26 weeks of gestation]); yawning (Supplementary Material S3 [fetal yawning at 27 weeks of gestation]); smiling (Supplementary Material S4 [fetal smiling at 27 weeks of gestation]); tongue expulsion (Supplementary Material S5 [fetal tongue expulsion at 27 weeks of gestation]); scowling (Supplementary Material S6 [fetal scowling at 26 weeks of gestation]); and sucking (Supplementary Material S7 [fetal sucking at 27 weeks of gestation]). Each facial expression has been described in detail previously [5]. The frequency of each fetal facial expression was assessed by an author (K.K.) who has extensive experience in the field; the results are shown as median and range values. The frequencies of the facial expressions at 25–27 weeks of gestation were compared using the Kruskal–Wallis 1-way analysis of variance by ranks test. The frequencies of each facial expression at 25–27 and 28–34 weeks of gestation were compared using the Mann–Whitney test. The data for 28–34 weeks were obtained from a previous study [5]. All calculations were performed using SPSS version 16 (IBM, Armonk, NY, USA). $P < 0.05$ was considered to be statistically significant.

3. Results

Twenty-four pregnant women agreed to participate in the study, none of whom smoked or had any complicating diseases. Median gestational age at examination was 27 weeks (range, 25–27 + 6 weeks). All infants were born at 37 weeks or later. The birth weights of all but 1 of the infants (which was small for gestational age but healthy) were within the reference range (between the 10th and the 90th percentiles) on the standard curve for Japanese neonates [6]. No congenital malformations, genetic disorders, or abnormal neurologic development was observed in any of the neonates.

As described previously [5], it was difficult to observe fetal faces when they were obscured by the umbilical cord or fetal extremities, or were facing the uterine or placental wall. Thus, placental and uterine walls were excluded from the ROI when possible. A suitable facial view was achieved in every case by moving the probe or asking the mother to alter her position.

The median frequencies of mouthing, yawning, smiling, tongue expulsion, scowling, sucking, and blinking at 25–27 weeks of gestation were 6 (range, 1–10), 1 (0–4), 0 (0–2), 0 (0–3), 0 (0–1), 0 (0–1), and 0 (0–2), respectively (Fig. 1). At 25–27 weeks, mouthing was significantly more frequent than the other 6 facial expressions ($P < 0.05$) (Fig. 1). Yawning was significantly more frequent than the other facial expressions, apart from mouthing ($P < 0.05$) (Fig. 1), and smiling was significantly more frequent than blinking ($P < 0.05$).

The frequencies of yawning, smiling, tongue expulsion, sucking, and blinking at 25–27 weeks were significantly different from those at 28–34 weeks ($P < 0.05$) (Fig. 2). However, the frequencies of scowling and mouthing did not differ between 25–27 and 28–34 weeks (Fig. 2).

4. Discussion

Several studies have involved 4D ultrasound examinations of fetal facial expressions late in the second trimester and early in the third trimester [5,7–9]. Kurjak et al. [8] detected variations in facial expression frequency in the second and third trimesters. The frequencies of all of the examined facial expressions peaked during the latter stages of the second trimester, except for that of isolated eye blinking, which increased at the start of week 24. During the early stages of the third trimester, decreased or unchanged fetal facial expression frequencies were observed [8]. In the study by Yigiter and Kavak [9], the frequencies of yawning, sucking, swallowing, smiling, mouthing, and tongue expulsion were highest at 24–32 weeks, whereas grimacing peaked at 28–36 weeks and eye blinking peaked after week 32. Kurjak et al. [7] also reported that concurrent eyelid and mouthing movements were the predominant expressions at 30–33 weeks. In the present and previous investigations [5], the most frequent facial expression was mouthing at 25–27 and 28–34 weeks of gestation; the frequency was significantly higher than that of the other facial expressions. The frequency of yawning was significantly higher than that of the other facial expressions, except for mouthing, at 25–27 weeks. Moreover, the frequencies of yawning, smiling, tongue expulsion, sucking, and blinking at 28–34 weeks were significantly higher than those observed at 25–27 weeks. The reasons for the discrepancies between these findings and those of other groups regarding the incidences of fetal expressions during the latter stages of the second trimester and the early stages of the third trimester are unknown. However, 4D ultrasound assessments of fetal facial expressions rely on the subjective judgment of the examiner, so inter-observer variability might be an issue with 4D ultrasound assessments of fetal facial expressions. Further studies are needed to determine appropriate levels of inter-observer agreement for such investigations. Moreover, an

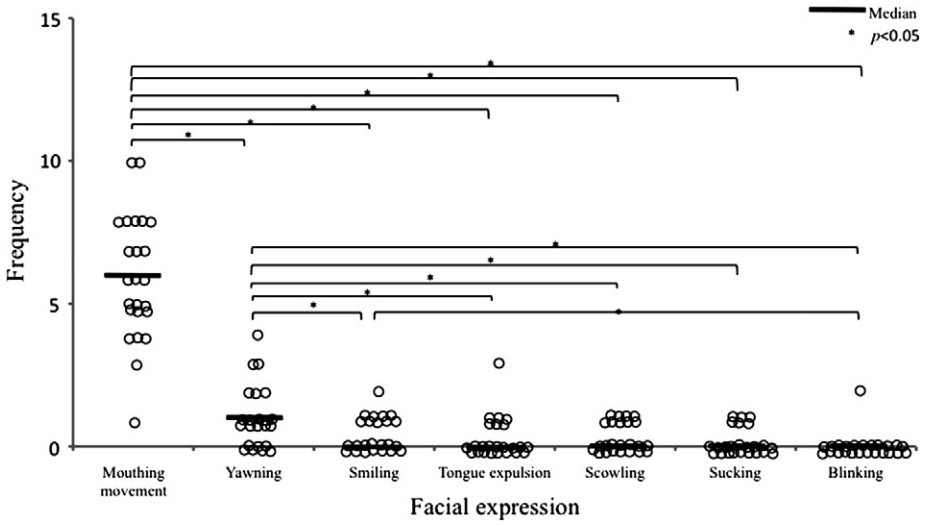

Fig. 1. Comparison of the frequencies of fetal facial expressions at 25–27 weeks of gestation.