

## MRI of the active second stage of vaginal delivery in real-time

Felix Victor Guettler<sup>1</sup>, Andreas Heinrich<sup>1</sup>, Christian Bamberg<sup>2</sup>, Jens Rump<sup>1</sup>, Bernhard Schnackenburg<sup>3</sup>, Maximilian de Bucourt<sup>1</sup>, Andreas Thomas<sup>1</sup>, Bernd Hamm<sup>1</sup>, and Ulf Teichgraeber<sup>1</sup>

<sup>1</sup>Department of Radiology, Charité - University Hospital Berlin, Berlin, Berlin, Germany, <sup>2</sup>Department of Obstetrics, Charité - University Hospital Berlin, Berlin, Berlin, Germany, <sup>3</sup>Philips Medical Systems, Hamburg, Germany

### Introduction:

Human childbirth is a complex, three-dimensional and dynamic process, in which the fetus navigates through the birth canal. Accurate models of the underlying anatomy are necessary for correct simulations of normal deliveries (1-3) and especially imperative to derive valid predictive factors for complicated deliveries. Pregnancy and vaginal birth stretches muscles, conjunctive tissues and nerves causing e.g. the damage of the pelvic floor, which can lead to secondary diseases such as stress urinary incontinence. Those assumptions are based on over 90% of the evaluation of the questionnaires (4, 5). Further examinations are necessary to objectify the correlation between pregnancy, birth and damage of the pelvic floor. The aim of this study is focused on the visualization of the active second stage of vaginal delivery in real-time through an open magnetic resonance imager to comply with modern safety standards in obstetrics.

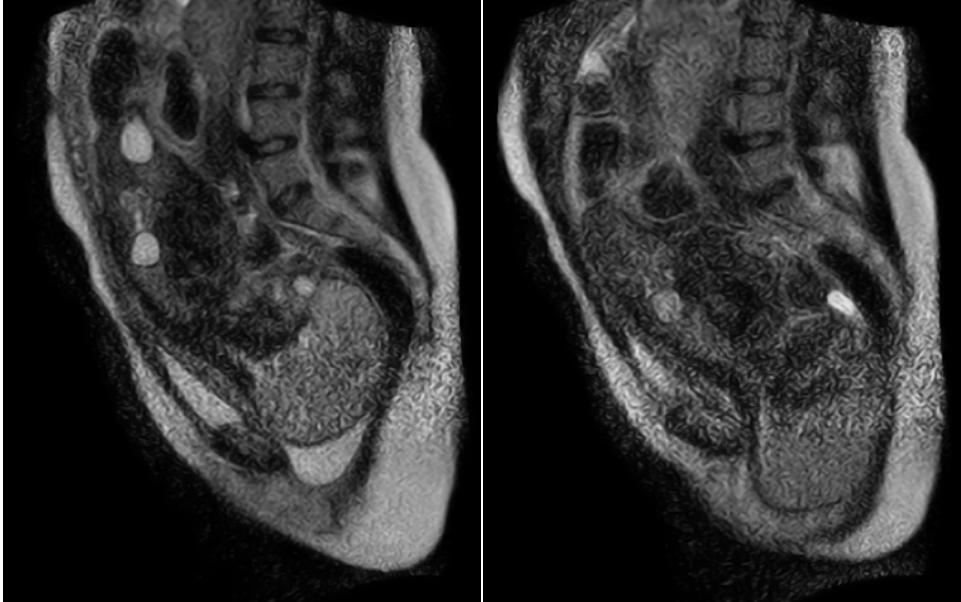
### Material and Methods:

All fetal MR-images from preliminary experiments and from birth were acquired on a Philips Panorama HFO scanner (42.58 MHz) and a cylindrical Philips BodySp-XL receiver coil. Six pregnant volunteers (up to 30 weeks) were examined in an MRI, clarifying three focal points before birth preparation. The first key aspect was to find a suitable positioning of the pregnant women with a good accessibility for the obstetricians and the possibility to quickly evacuate the test person with its child from the magnet room, providing medical treatment in the anteroom. The second focal point a MR-compatible cardiotocograph (CTG) was the development and test on the pregnant volunteers. The last focal point aimed to develop a birth adequate dynamic sequence with the aid of the pregnant women. In this process, mostly single-shot TSE sequences with a TR between 1000 and 2500ms were analysed. To reduce the volume of the sequences, the "SofTone mode" parameter was activated. General instruments typically used in obstetrics were provided MR-compatible to enable interventions inside the magnet room. The expulsive phase was visualized with an interactive Single-Shot TSE (TR 1600 ms, TE 150 ms, DRIVE pulse, single slice of 6 mm, pixel size 1.4x1.5 mm, FOV 380x285 mm).

### Results:

The available space in the open MRI allowed a traditional childbirth position (supine position, head ahead). The interactive single-shot TSE sequence was robust to the movement artifacts of the fetus in the womb, and also allowed to monitor the expulsion phase in the interactive mode (repeated image acquisition) of the scanner. During this phase, one MR image was acquired in 600 ms and further image acquisition was repeated every 1600 ms (TR). All through the second stage of labor, the interactive sequence could trace the fetal rotation and visualize the maternal anatomy including uterine contractions. Contractions help pushing the baby's head through the birth canal leading to a stretching and compression of the muscles (see Figure 1). At the same time, the muscles are pressed into the tissue, which is itself compressed to less than half the original size. The increasing stretching and compression in the process of contractions was traced over time. Contemporaneously, it became clear how intensive and how long the rectum and the muscles are actually pressed against the coccyx to enable the child to pass the birth canal.

**Figure 1:** With a dynamic single-shot TSE sequence, the expulsive phase could be retraced over time. During a contraction pause, the child laid on the pelvic floor of the mother (left picture). The following contractions pushed the child through the birth canal. A 48 second older image (right picture) shows how the child has to stretch the birth canal to pass it. Thus, the stretching of the penultimate contraction was not sufficient to leave the uterus, so that the child fell back into the initial position (as in the left picture). After a last contraction pause, the child could finally be born.



### Conclusions:

The acquisition of real-time cinematic MRI series during the active second stage of human childbirth using MR-compatible CTG seems to be suitable for an improvement of the models for birth simulation as well as for further cause study of obstructed labor and birth complications.

### References:

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