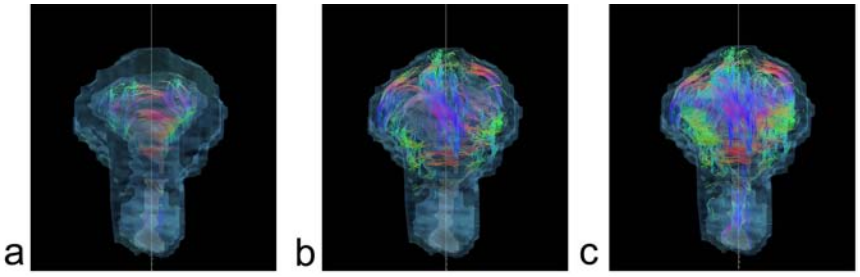
DIFFUSION TENSOR IMAGING OF THE NORMAL HUMAN UTERUS IN VIVO

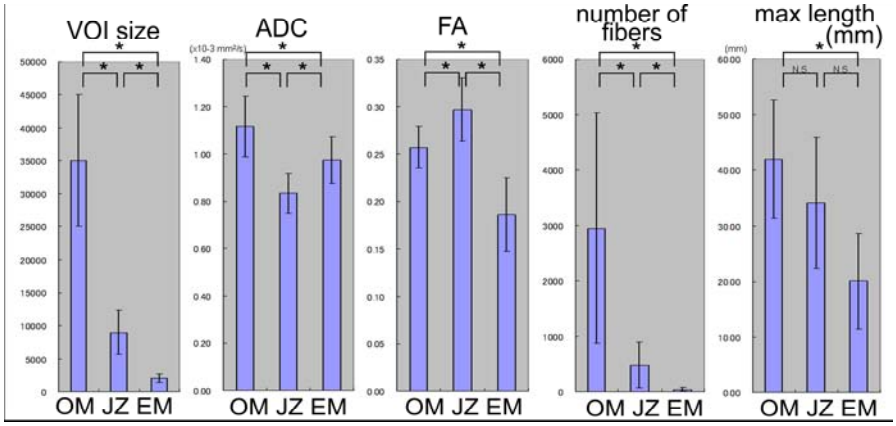
Koji Fujimoto[1], Aki Kido[1], Tomohisa Okada[1], Masato Uchikoshi[2], and Kaori Togashi[1]
[1]*Department of Diagnostic Imaging and Nuclear Medicine, Kyoto University Graduate School of Medicine, Kyoto, Japan,* [2]*Siemens Japan K.K., Tokyo, Japan*



Introduction and Target audience: The muscular layer of the uterus, or myometrium, is divided into three layers. The presence of circularly arranged muscular fibers in the subendometrial myometrium were reported by using light microscopy. According to these reports, the stratum vasculare (an intermediate highly vascularized area) consists of a three-dimensional mesh of short muscular bundles[1] or two counter-rotating systems of spirals[2], but the actual three-dimensional architecture has been debated for a long time. DTI can provide information about structural orientation in tissues in vivo. Considering the preservation of fertility in those patients undergoing uterine myomectomy, evaluation of structural restoration is important for the next pregnancy. It might also give additional information for assessing the possibility of a vaginal delivery or continuation of pregnancy in women with a history of Caesarian section[3] or those who have undergone surgery for Müllerian duct anomalies. Since the uterus consist of three zonal layers, we hypothesized that fiber architecture of the uterus in vivo is closely related to each zonal layers and those quantitative measurements such as number of fibers, fiber length, FA, ADC are different for each layers.

Purpose: To investigate the feasibility of applying DTI in vivo among normal volunteers and compared quantitative measurements among three zonal layers of the uterus. We also conducted qualitative analysis by classifying the depicted fibers and investigated rate of visualization.

Materials and Methods: DTI of the uterus was performed for nine healthy women of reproductive age (mean age 32) on a 3T scanner (MAGNETOM Trio). DWI was obtained in a plane parallel to the long axis of the uterine corpus. The parameters for DWI were: TR/TE, 7000/62 ms; matrix size, 128x104; FOV, 250x203 mm; b-values, 0 and 700 sec/mm^2; 12 diffusion directions plus one null. Nominal voxel size, 2x2x2 mm with no inter-slice gap; acquisition time, 3 min 23 sec. For offline data processing, an ADC map and fractional FA map were first calculated from DWI datasets by using Diffusion Toolkit (http://trackvis.org/dtk/). Second, fiber tracking was performed by using a FACT algorithm with the angle threshold of 35°. Then, a three-dimensional VOIs for the whole uterus, three layers of the outer myometrium (OM), the junctional zone (JZ) and the endometrium (EM) were drawn separately on the DWI data with a b-value of 0 sec/mm^2 by using 3D Slicer (http://www.slicer.org/). By using TrackVis (http://trackvis.org/), fibers were visualized separately by using these VOIs as masks to limit visible fibers (Figure 1). Volume size, the mean ADC, mean FA, number of fibers and maximum fiber length for each VOI (i.e., OM, JZ and EM) were measured. For visual evaluation, fibers were classified into 12 groups and were classified by their shape (circular or longitudinal) and their location (OM, JZ or EM). Two radiologists rated visualization scores for each type of the fibers using a three-point scale: 1, not visualized; 2, probably visualized, but uncertain; and 3, definitely visualized. For each quantitative measurement (i.e., VOI size, mean ADC, mean FA, number of fibers and maximum fiber length), statistical significance between the layers was examined using two-tailed paired Student's t tests.



Results: ADC (x10-3mm^2/s) was highest for OM (1.12), followed by EM (0.97) and JZ (0.83) (OM vs. JZ, P < 0.0001; JZ vs. EM, P = 0.0001; OM vs. EM, P = 0.0057). FA was highest for JZ (0.297), followed by OM (0.257) and EM (0.186) (OM vs. JZ, P = 0.0002; JZ vs. EM, P < 0.0001; OM vs. EM, P < 0.0001). Fibers were longest in OM (42.0mm), followed by JZ (34.2mm) and EM (20.0mm). Circular orientation was observed in 50% (36/72) of fibers in OM and in 44% (32/72) in JZ.

Discussion: Zonal difference in FA values might reflect differences in the density of well-aligned fiber bundles. Identification of circular systems of fibers was relatively easier in the JZ than in the OM. The highest FA in the JZ was compatible with the result of visual evaluation. These results are consistent with previous reports that uterine peristalsis was mainly identified in the JZ using cine-MRI.

Conclusion: This study showed that the quantitative and qualitative DTI/DTT of the normal uterus in vivo was capable of demonstrating zonal difference in the microstructure of the uterus. The fiber architectures analyzed in this study were similar to those described in previous studies.

Ref.: 1. Wetzstein R. Arch Gynakol 1965;202:1-13. 2. Goerttler K. Arch Gynakol 1968;205(4):334-342 3. Fiocchi F, et al. Br J Radiol 2012.