# Reproducible quantification of fiber integrity profiles in the cingulum and the fornix using an experimental 32 channel head coil

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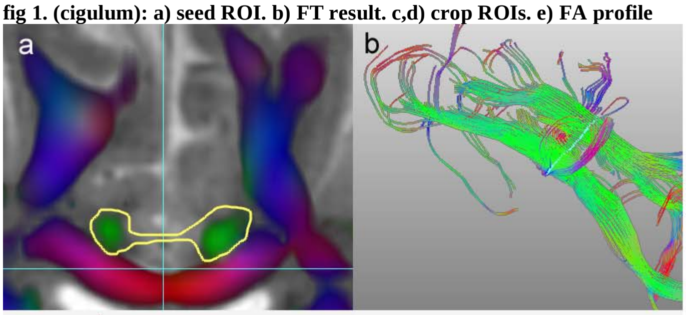
## Introduction

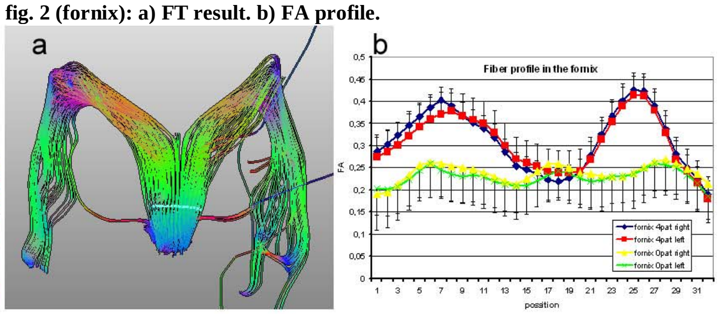
Recently, we have shown that the use of parallel imaging (PI) can reduce distortion effects on DTI data and consequently improve fiber tracking (FT) results (1). In this study we further explore the advantage of PI for FT and fiber integrity evaluation. We used a prototype 32 channel head coil and compared this data with data from a 12 channel head coil. Specifically, we investigated small strongly curved structures that currently pose a problem regarding full delineation of the structure and consequent stable extraction of fiber integrity, even when using 3T and PI. We present a novel approach for the evaluation of the fiber integrity in such small fibers. Structures investigated here include the fornix and the cingulum, both part of the limbic system. Since this system is involved memory processing and emotional tasks, it is implicated in the pathophysiology of psychiatric diseases such as autism, borderline personality disorder and Alzheimer's disease.

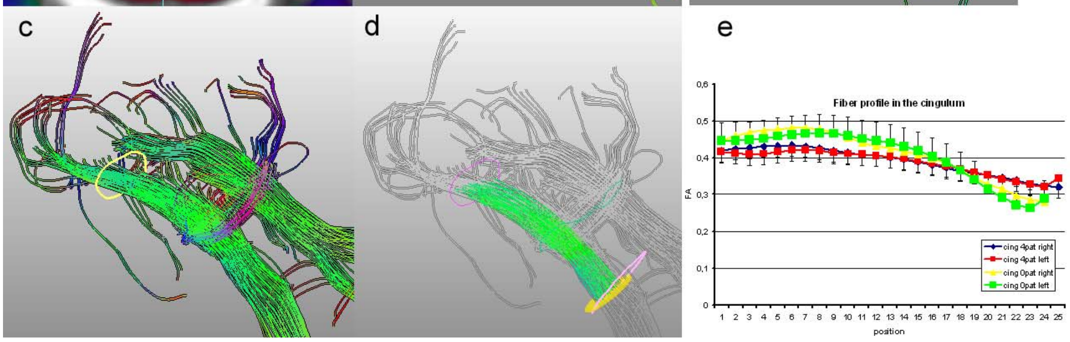
## Methods

We included 10 healthy volunteers in this study. All were scanned using a 3T scanner (Tim Trio, Siemens Erlangen) and a 12 channel commercial- and a prototype 32 channel head coil, gradient strength 40 mT/m. Imaging was performed using non parallel imaging and accelerations factors (PAT) of 2, 3 and 4 with GRAPPA reconstruction. We used a SSEPI: TR/TE (nopat, 2/3/4 pat): 9200/127; 6600/95; 6000/89; 5600/84, FOV 320 mm, matrix of 128x128, 50 axial slices, thickness 2.5 mm, 12 gradient directions and two b-values (0 and 1000 s/mm$^2$) and 4 averages. Additional 3D T2 imaging was performed for anatomical overlay. All data was processed using NeuroQLab (MeVis Research, Bremen). Identical tracking parameters were used for all fiber representation (no FA threshold, inner product 0.3). All FT was started from a single seed ROI, the FA was measured over a set anatomical distance between two crop ROIs for the cingulum (fig. 1a-e) and the fornix (fig 2a-b). FA profiles over distance were compared between non PI and 4 PAT. Additionally, data from 12 and 32 channel coils were compared.

**fig 1. (cigulum): a) seed ROI. b) FT result. c,d) crop ROIs. e) FA profile** **fig. 2 (fornix): a) FT result. b) FA profile.**




## Results

Using the 12 channel coil, neither the cingulum nor the fornix could be reconstructed in full using only one start ROI (data not shown). Thus quantification over a distance was not possible. In fig. 1 the full sequence of evaluation is presented. A full representation of the cingulum (1b) and the fornix (2a) can be achieved. Without further processing (additional start/exclude ROIs), 2 crop ROIs are placed at anatomically defined areas within the structure (1c-d) and the fiber density is show for the cingulum (1e) and the fornix (2b). Fiber profiles without (green/yellow) and with (red/blue) PI are similar in the cingulum, the data shows a SD of +/- 0.07 and +/- 0.04 f without PI and with PAT4 respectively when comparing the 10 subjects FA profiles. In the fornix, the profiles with and without PI differ greatly (fig 2b). Without PI, the FA basically shows a mean of 0.23 and a relatively large SD of +/- 0.06. Using PAT4, a significantly higher FA is measured with two maxima both at densely packed parts of the fiber in the lateral and medial horizontal part of the tract (position 7 and 26 respectively) and a minimum at the site of greatest curvature (position 18). The overall SD is lower than without PI with a mean value of +/- 0.03. Repeated evaluation of the same subjects using this method showed variances below 5%.

## Discussion

Using only 4 min of acquisition time, using a 32 channel and PI, the cingulum and the fornix could be depicted in a reproducible fashion that cannot be achieved using a 12 channel coil, even when applying PAT4. This may be due to two effects: due to optimized design, the 32 channel coil has an improved fill factor and SNR. Also, using the 32 channel coil, higher PAT factors can be used that further reduce the sensitivity to minor disturbances in field homogeneity. This may explain why there are few differences in FA profiles in the cingulum when comparing 0 and 4 PAT. Here the available SNR is the main factor to be able to delineate the structure, whereas in the fornix, since it is a highly curved structure, the reduced sensitivity to inhomogeneities may lead to a more complete depiction of the tract when using 4 PAT. The shown method for fiber integrity measurement shows a high reproducibility and minimal variance in healthy controls even in such a delicate tract. The found fiber signature in the fornix opens a venue of research in diseases where the limbic system is thought to be affected. Data could be further optimized when increasing the number of gradient direction and an imaging time of 10 minutes would still be agreeable in most research settings

## References

1. Stieltjes et al, ISMRM 2007 pg. 1564: Advantages of parallel imaging for DTI-based fiber tracking at 3T