SUPPLEMENTAL MATERIAL

Supplemental Methods:

Stability of the imaging system over long-duration scans:

In preliminary design of the pulse sequence, we found, through trials, that diffusion gradient amplitudes and imaging gradients needed to be adjusted to a level that was below the maximum capability of the scanner in order to achieve long-term stability. Imposing these constraints effectively limited the achievable diffusion b value and spatial resolution, and added to the scan duration by increasing the minimum Repetition Time (TR).

To assess the stability of the imaging system over the long duration scan, b0 (non-diffusion weighted) images were acquired at the beginning ($b0_1$, t=0 hours) and the end of the scan ($b0_2$, t=~50 hours). These two image stacks were compared for spatial registration and SNR consistency. Further, two separate DTI tensors were reconstructed from these data using first, the $b0_1$ volume with the 15 diffusion-weighted images, and second, the $b0_2$ as the non-diffusion weighted volume. We found that the resulting angle difference in the fiber orientation reconstructed using $b0_1$ and $b0_2$, was insignificant inside the myocardium (<0.25 degrees), indicating that there was virtually no effect of the long scan duration on the acquired images. The test procedure was performed in a swine heart with the similar scan parameters as the human atrial scan.

In addition, the reproducibility of the fiber map reconstruction was tested by repeating the image acquisition for one of the human hearts in this study (heart 7). The tractography result of the repeat scan was essentially identical to the original scan.

Tractography visualization:

The original tracking algorithm (FACT) that generated tracts from each voxel in the atria

produced very dense fiber maps (~1M tracts in the whole atria). Showing all of the generated tracts would have made the visual tracing of the distinct bundles impossible, and obscured the endocardial layer of fibers. Thus, to achieve visualization appropriate for the goals of the study, we implemented a two-step process. In the first step, we performed a pre-selection on the original tractography results: We initially calculated the regional tracts' density by counting the number of tracts passing through each voxel. We then assigned a density score to each tract, which is the median of the densities of all the voxels that the tract passes through. Further, we grouped all the tracts into N=50 distinct bins, based on their density scores. Following that, a random sampling process was applied to each bin to select a pre-calculated number of tracts for the visualization. This number was inversely proportional to the bin density. This processing step resulted in a better visualization with fewer gaps in regions with lower density of tracts. In the second step, the resulting tracts were culled down by uniform sub-sampling of the list of the selected tracts from the previous step. This culling down process was performed progressively in TrackVis until we achieved a visualization that captures the major features of the atria.