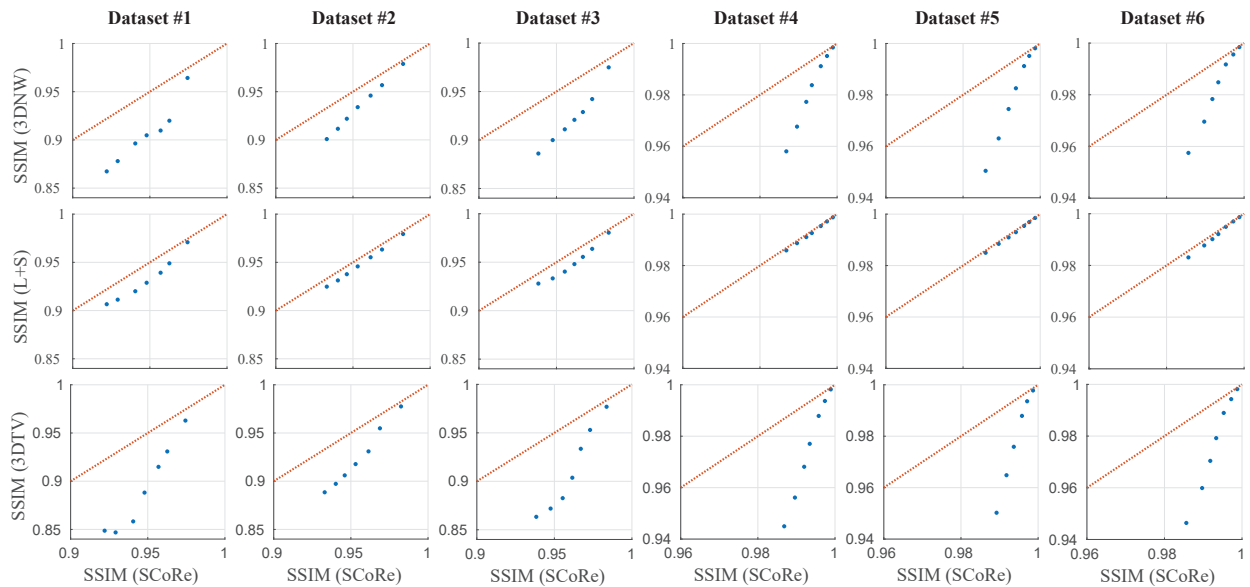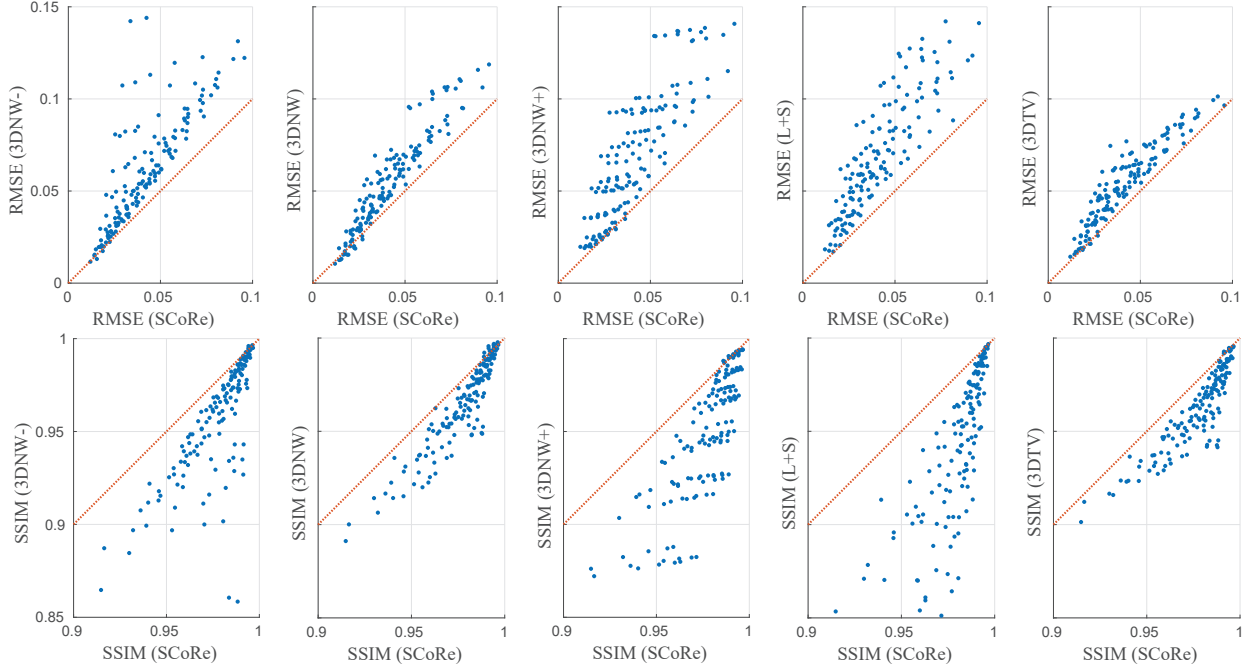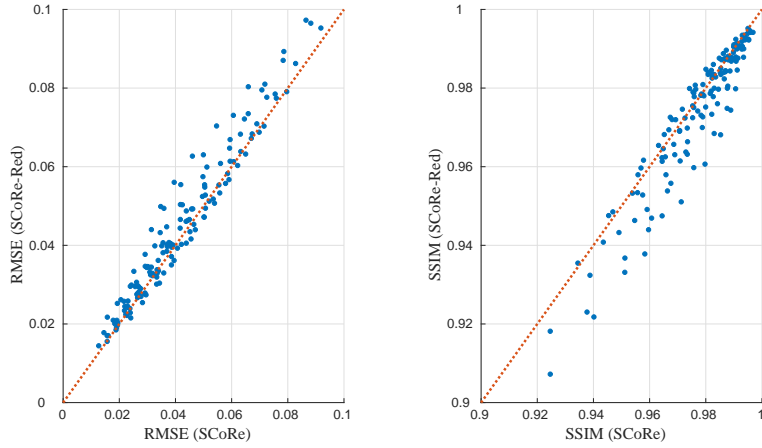Supporting Information Figure S1: A representative VISTA pattern with $R = 9$. Here, PE represents the phase-encoding dimension.

Supporting Information Figure S2: SSIM comparison of various image reconstruction methods for the in vivo study with RU. The identity line is shown in red, and the seven dots in each panel represent different acceleration rates ($R = 2, 4, 6, 9, 12, 15, 18$). In all cases, the values of SSIM for SCoRe monotonically decreased with R.

Supporting Information Figure S3: Application of SCoRe with finite difference operators used as sparsifying transforms. In contrast to Figure 2, where subbands of 3D NWT are used as eight distinct sparsifying transforms, two spatial and one temporal finite difference operators are used as three distinct sparsifying transforms. RMSE (top row) and SSIM (bottom row) are compared for various image reconstruction methods for the simulation study.

Supporting Information Figure S4: RMSE (left) and SSIM (right) comparison of SCoRe with its reduced version, SCoRe-Red. For SCoRe, the regularization weights for all eight subbands were auto-tuned independently. In contrast, for SCoRe-Red, the NWT coefficients were divided into two groups, i.e., LLL and non-LLL, and two resulting regularization weights were auto-tuned independently.