Elliptical Field of View in PROPELLER MRI

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Many advanced techniques like parallel imaging, fast trajectories (spiral scans) and accelerated scans (turbo PROPELLER) have been proposed to minimize scan time. Supporting a field of view (FOV) that just circumscribes the object of interest is a basic approach to controlling scan time. In radial trajectories this is achieved by non-uniform angular sampling [1, 2]. PROPELLER is also radial in nature; hence non-circular FOVs can be supported by a similar approach.

Regular PROPELLER scans are designed based on the minimum number of blades ($Nblades_{min}$) required to fully cover k-space. For a given effective matrix (M_{eff}) and number of phase encodes per blade (L), $Nblades_{min} = ceil(1.5\ M_{eff}/L)$ [3]. Increasing the number of blades beyond the minimum required has many advantages: improved SNR, better motion correction and robustness to data corruption as blades can be discarded with little effect on the final image. A non-uniform angular sampling scheme for PROPELLER must preserve this characteristic.

METHODS: Blade width in k-space depends on the extent of the object in the direction perpendicular to the blade angle. Hence for non-circular FOV blade widths vary with angle. Given the ellipse ratio *(R = EllipseShortAxis / EllipseLongAxis)*, M_{eff} and L, the $NbladesEfov_{min}$ for an elliptical FOV can be determined as:

$$b = L/2 \qquad a = b/R \qquad h = [(a-b)/(a+b)]^2$$

$$\text{ellipse area} = a_e = \pi ab \qquad r_a = (a_e/\pi)^{0.5}$$

$$\text{ellipse perimeter} = p_e = \pi(a+b)[1+(3/h)(10+\{4-3h\}^{0.5})] \qquad r_p = p_e/2\pi$$

$$NbladesEfov_{min} = \text{ceil}[\pi/\{2\ \sin^{-1}[(r_a+r_p)/Meff]\}]$$

N is then determined by operator requirements. The angular sampling scheme for a predetermined N is given by

$$k_1 = 0.3477\ (1-R) \qquad k_2 = k_1^3$$

$$\theta_{eFov} = \theta_{cFov} + k_1 \sin[2\ \theta_{cFov}] + k_2 \sin[4\ \theta_{cFov}]$$

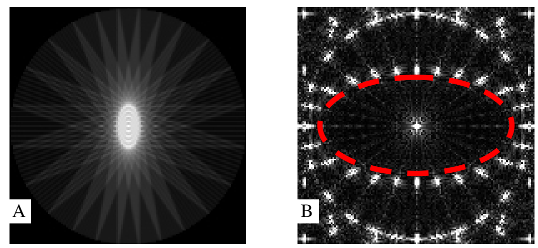

Fig 1. A PROPELLER trajectory for elliptical FOV (A) and the corresponding point spread function (B).

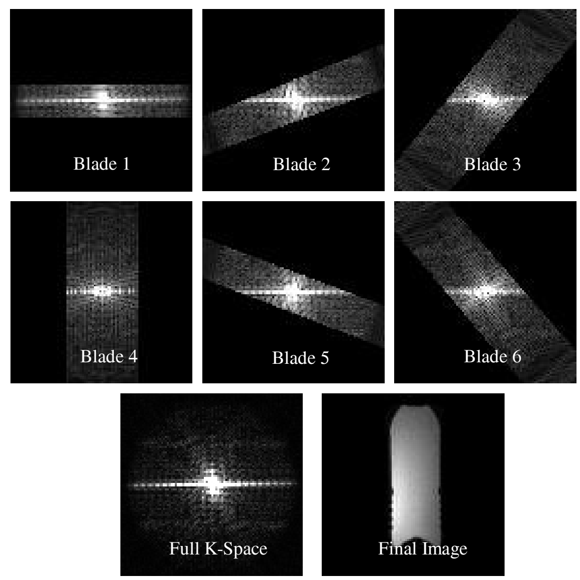

Fig 2. Individual blades from an actual scan depicting k-space coverage with the resulting image and k-space

RESULTS & DISCUSSION: The use of non-uniform angular sampling as described here reduces $Nblades_{min}$ for a scan. As shown in fig.4 the reduction is evident for $R<0.6$. Even for configurations with modest reductions the saving in overall scan time for sequences that acquire large number of images like diffusion weighted PROPELLER will potentially be significant. The reduction in N however does not significantly affect the final image quality as demonstrated in fig.3.

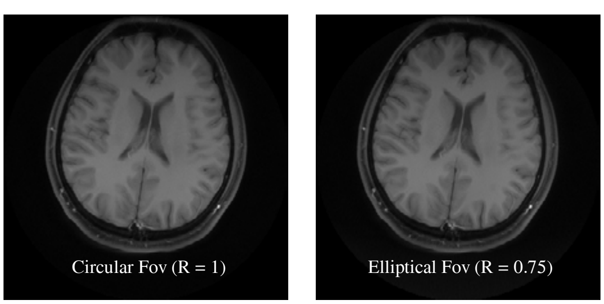

Fig 3. PROPELLER scans supporting different Fovs in contrast to a each other. Collected on 3T scanner with Tr = 700ms and Te = 23ms

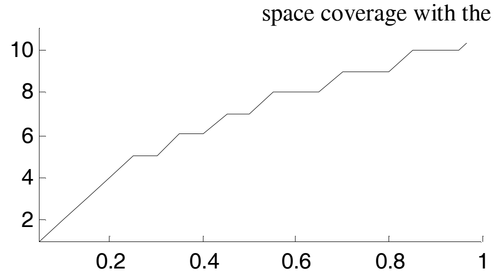

Fig 4. Minimum Number of blades as a function of R (L = 41 and Effective Matrix = 257).

REFERENCES:

[1] Larson P. E. et al, Proc. ISMRM 14:340 (2006)
[2] King K., MRM 39:448-456 (1998)
[3] Pipe J. G., MRM 43:963-969 (1999)