24 Matrix Size: Phase Encoding

Fig. 24.1 presents sagittal T2-weighted images of the midlumbar spine demonstrating mild degenerative disk disease (loss of disk hydration, with the nucleus pulposus not being of normal high signal intensity). Fig. 24.2 presents sagittal T1-weighted images, in a different patient, of the lower thoracic and upper lumbar spine at the level of the conus medullaris, revealing a benign chronic compression fracture of L1, with anterior wedging.

The choice of phase encoding matrix determines the number of pixels along the phase encoding direction of the acquired FOV. This determines how many different lines of k space will be filled during the acquisition. Thus, the number of phase encoding steps directly affects scan time. Flow and/or motion artifacts also are propagated along the phase encoding direction. Additionally, assuming the display and acquired FOV are identical, if there is significant signal from excited tissue outside the FOV, it will wrap, or fold over, into the displayed FOV (see Chapter 92). This occurs in both the phase and frequency direction and is overcome by oversampling. Oversampling increases the scan time when applied in the phase encoding direction (except for single shot techniques), assuming that all other parameters and in particular the number of signals averaged are held constant.

Fig. 24.1a was acquired using a 256 read matrix and 128 phase matrix. Fig. 24.1b was acquired with a 256 read and 256 phase matrix. The phase encoding direction
in both examples was in the craniocaudal direction, with 100% oversampling. The scan time for Fig. 24.1a was 2:08 and for Fig. 24.1b 4:08. Although the scan time for Fig. 24.1b was twice that of Fig. 24.1a, with an acquired FOV of 280 mm, the pixel dimension in the phase direction for Fig. 24.1a was 2.2 mm and that for Fig. 24.1b 1.1 mm. Fig. 24.1b thus has higher spatial resolution. As an aside, it is worthwhile noting that selecting the phase direction to be craniocaudal for sagittal T2-weighted fast spin echo (FSE) imaging of the spine can substantially reduce the conspicuity of CSF pulsation artifacts.

The image in Fig. 24.2a was acquired using a read matrix of 512 and a phase matrix of 256. Fig. 24.2b was acquired using a read matrix of 512 and a phase matrix of 512. The phase encoding direction was anterior to posterior in both instances. The scan time for Fig. 24.2a was 3:38 and that for Fig. 24.2b 7:15. With the higher matrix size, the pixel dimension in Fig. 24.2b in the phase encoding direction is reduced and spatial resolution increased (thus, the image appears less blurred). The pixel dimension in the phase (and read) direction for Fig. 24.2b is just over 0.5 mm. One will also note that as the pixel size is reduced, SNR is reduced, with the result being an increase in the overall "grainy" appearance of the image. However, one should recall that with pixel size constant, increasing the phase encoding matrix actually increases SNR (with SNR ∝ \sqrt{\text{number of phase encoding steps}}).

In summary, spatial resolution can be improved by increasing the number of phase encoding steps, which results in a smaller pixel dimension along the phase FOV. However, because this increases the number of k space lines acquired, it also increases scan time. Reducing the pixel size, however, in either the read or phase direction, reduces SNR, assuming all other parameters are held constant.