29 Fast Spin Echo Imaging

The images illustrated in **Fig. 29.1** were acquired using (a) conventional and (b) fast spin echo techniques. The use of fast or turbo spin echo (FSE, TSE) imaging has become routine in MRI today. A spin echo sequence employs a 180° RF pulse (typically) to create the echo, which also corrects for dephasing effects from slight field inhomogeneities and chemical shift. In a conventional spin echo sequence, a phase encoding gradient of defined amplitude is applied prior to the collection of the echo during readout. The amplitude of the phase encoding gradient determines the line in k space that will be filled as the echo is sampled. In a conventional spin echo sequence, one line of k space is filled during each repetition (TR period) of the pulse sequence. In an FSE sequence, a series of 180° pulses produces a train of echoes during a single TR period, as illustrated in **Fig. 29.2**. The number of echoes produced in a single TR period is known as the echo train length (ETL). The phase encoding gradient amplitude will vary prior to each echo in the train so that each echo will fill a different line of k space. In this way, multiple lines of k space are filled during a single TR period. The number of lines filled in a single TR thus also corresponds to the ETL. As an example, using an ETL of 16, 16 lines of k space will be filled during a single TR period. If a phase encoding matrix of 256 is selected, rather than requiring 256 repetitions of the pulse sequence to fill all the lines of k space (assuming 1 for the number of signals averaged [NSA]),

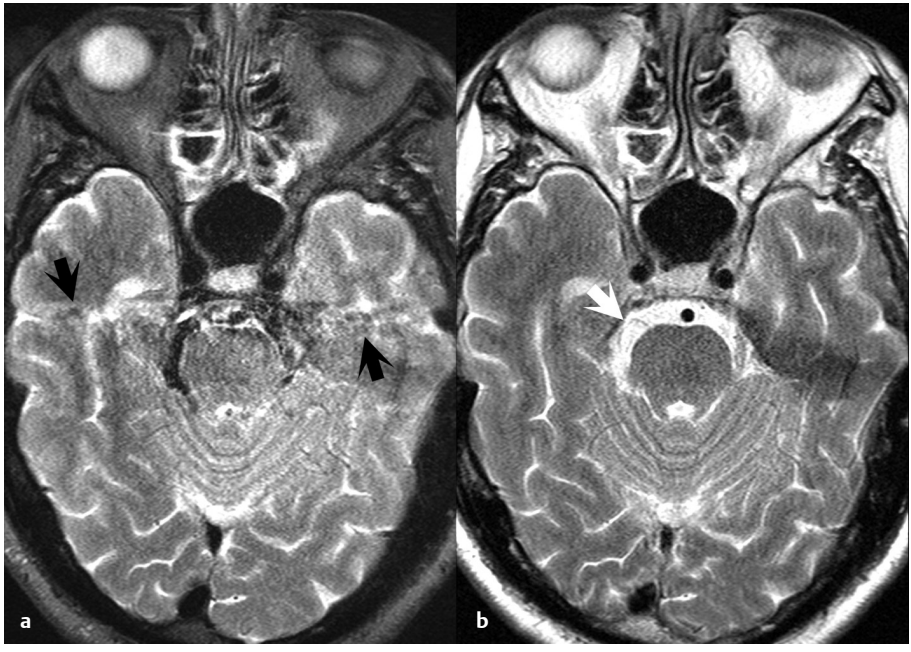

Fig. 29.1

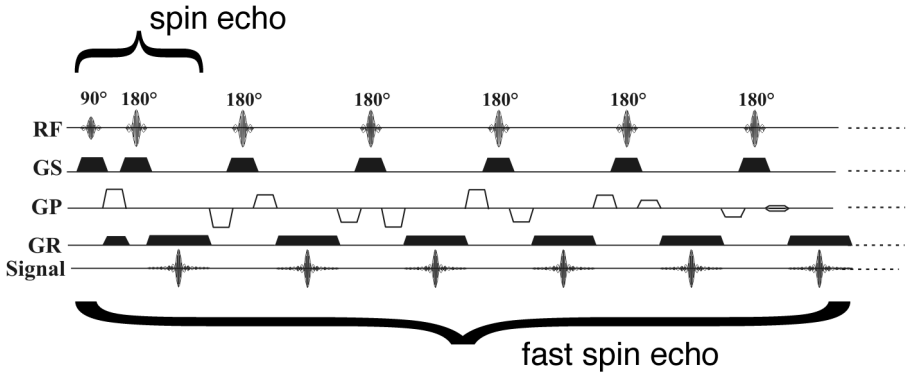

Fig. 29.2

only 16 repetitions would be required (256/16 = 16). Increasing the ETL to 32 would require only eight repetitions to fill all 256 lines of k space. The use of FSE sequences has not only greatly reduced the time required to obtain MR images with a long TR, but allows the use of high TR times for improved tissue contrast.

To demonstrate the power of FSE, consider the image in **Fig. 29.1a**. This was acquired using conventional spin echo technique with a TR of 3500 msec and a TE of 85 msec. The total scan time was 10 minutes, 51 seconds. The FSE sequence (**Fig. 29.1b**) was acquired using the same TR and TE but it had an ETL of 19. By filling 19 lines of k space in each TR period, the scan time for the FSE images was only 35 seconds (10:51 divided by 19). The multiple 180° pulses also help reduce pulsation and flow artifacts, on the basis of reduced voxel dephasing and phase shifts due to the short interecho spacing. Note the higher, more uniform cerebrospinal fluid (CSF) signal intensity around the pons (white arrow) and improved depiction of flow voids in the basilar and internal carotid arteries in the FSE images, together with reduced ghosting (black arrows) from CSF, vessels, and the globes.

As previously mentioned, increasing the ETL reduces scan time; however, this is not without penalty. A long ETL reduces the number of slices that can be acquired in a single scan. Also, the longer the ETL, due to intrinsic T2 decay, the greater the edge blurring if a short effective TE is chosen and the greater the (artifactual) edge enhancement if a long effective TE is chosen. The blurring/edge enhancement can be minimized by the use of higher receiver bandwidths, which typically result in a shorter "readout" period and thus reduced time (spacing) between echoes (the critical factor involved). In addition, the multiple 180° RF pulses cause fat to remain high in signal intensity even with long echo times (due, in part, to rephasing of stimulated echoes). With a spin echo T2-weighted scan, fat will be of intermediate to low signal intensity, whereas with a matching fast spin echo T2-weighted scan, fat will be high signal intensity. This effect is strikingly demonstrated in **Fig. 29.1**, with both scalp fat and fat within the orbit having high signal intensity on the FSE image. Thus, fat suppression (see Chapter 40) is often employed with T2-weighted FSE imaging for the evaluation of soft tissue lesions in body imaging.