Chapter 2 Imaging Techniques of MRCP
2.1 Technical Development

2.1.1 Gradient Echo Sequence

In 1991, Wallner et al. [1] and Morimoto et al. [2] first reported MR cholangiography using a steady-state free procession (SSFP) gradient echo sequence. However, the sequence required long period of breath holding, and the spatial resolution was inadequate to allow satisfactory imaging of the pancreatic duct. The reason was that the gradient echo sequence was susceptible to magnetic field inhomogeneity and motions such as gastrointestinal peristalsis, pulsation of the aorta, and abdominal wall movement.

2.1.2 Spin Echo Sequence

2.1.2.1 Fast Spin Echo Technique

In 1994, Takehara et al. [3] proposed the fast spin echo (FSE) technique with a long echo train that yielded heavily T2-weighted MRCP images with higher spatial resolution than the SSFP sequence. The FSE technique had a higher signal-to-noise and contrast-to-noise ratio, and was less susceptible to motion and magnetic field inhomogeneity. Furthermore, advances in the MRI system, such as the introduction of phased-array multicoils, improved the spatial resolution. Application of a fat saturation technique diminished the background signal due to intraabdominal fat, contributing to better quality of the MRCP images. Consequently, satisfactory images of the pancreatobiliary tree were acquired with the FSE technique [4], although routine visualization of the nondilated pancreatic duct was still difficult. The major disadvantage of the FSE technique was that it required a long acquisition time and a breath-holding scan was difficult to acquire in most patients. As a result, image quality was deteriorated by respiratory motion artifacts [5]. Another drawback of FSE technique was that the sequence required maximum intensity projection (MIP) for postprocessing, which caused a high false-positive rate of ductal stenosis due to misregistration artifacts [6].

2.1.2.2 Single-Shot Rapid Acquisition by Relaxation Enhancement (RARE) Technique

In 1995, Laubenberger et al. [7] proposed the single-shot rapid acquisition by relaxation enhancement (RARE) technique, which made it possible to acquire all the echo signals (240 echoes) from a single 90°