13.1 Introduction

The development of MR-compatible biopsy needles (Lufkin et al. 1987; Mueller et al. 1986; van Sonnenberg et al. 1988) has made it possible to exploit the high contrast and the multiplanar imaging capabilities of MR (Fig. 13.1) for MR-guided biopsy procedures of all kinds (Adams et al. 1997; Duckwiler et al. 1989; Hathout et al. 1992; Mueller et al. 1989; Pitt et al. 1993). A growing understanding of the artifacts induced by these devices when used with different sequences (Ladd et al. 1996; see Chap. 4). The author’s experience has been gained on a 1.5-T system. The principles stated here can be easily transferred to other high-field systems. For field strengths below 1 T, two main differences have to be taken into account. Firstly, the lower the field strength, the more the acquisition...
time will need to be prolonged or the signal-to-noise ratio will be decreased for any given resolution. Secondly, susceptibility artifacts will be less pronounced. While it has been shown that MR-guided biopsies are possible on low- and mid-field systems (Chaps. 1–3), the demands for sequence optimization are more crucial than with high-field systems in order to circumvent the disadvantages of a lower signal-to-noise ratio and decreased imaging speed.

13.2
MR Imaging and Needles: General Considerations

13.2.1
Choice of Sequence

The ideal sequence for MR-guided biopsies has to fulfill four requirements: firstly, for obvious reasons it has to be quick. But “quick” is, of course, a relative term, and the demand for image speed depends among other factors on the region to be biopsied and the patient’s compliance. In general, the acquisition of a single image should at least not take much longer than that of a conventional CT slice. Secondly, the needle artifact should be big enough to be easily detected, but not so big as to obscure the lesion to be punctured (SINHA et al. 1989). Thirdly, there must be sufficient contrast between the lesion and the adjacent tissue, such as between the lesion and the needle artifact. As the needle artifact will tend to be black whichever sequence is used, and as most pathology is brighter on T2- than on T1-weighted sequences, one might, in general, expect T2-weighted sequences to be advantaged. Fourthly, vulnerable structures along the puncture tract have to be clearly depicted by the ideal sequence. This implies that there must be conspicuity of vessels, whether they flow perpendicular to or within the imaging plane. Delineation of other anatomic structures, such as bowel, kidneys or lung parenchyma, is of interest depending on the location of the lesion and the biopsy pathway.

There is no doubt that it is impossible to fulfill all four demands perfectly with one single sequence. Therefore, compromises will have to be accepted, and it might be advisable to use more than one sequence for planning the biopsy procedure, and maybe even during the monitoring of biopsy itself.

13.2.2
Temporal Versus Spatial Resolution

A prerequisite for any standard MR-biopsy sequence is that it is easy to perform during a breath-hold. Although, in principle, it is possible to apply sequences with a longer duration for biopsies outside the abdomen, this would significantly lengthen the procedure itself. Speed adds considerably to patient comfort because it shortens the biopsy procedure itself. Furthermore, the use of fast or ultrafast sequences reduces the risk of accidental displacement of the needle by breathing, coughing or other movements. The lesion to be punctured will usually be at least 10 mm in size and the artifact caused by the needle will be in the range of 5–10 mm. Correspondingly, spatial resolution can be sacrificed for temporal resolution either through a reduction of phase-encoding steps, which will reduce the matrix and resolution proportionally, or by applying a spin-echo sequence with a high turbo factor, which will cause widening of the point spread function and blurring in the image (MULKERN et al. 1990; VLAARDINGERBROEK and DEN BOER 1996). Both methods are feasible to reduce the acquisition time of a sequence, but they should be applied in such a way that a robust, standard sequence is created which can be employed in all kinds of cases without the need for modifications. This allows the physician to become familiar with the contrast and size of the needle artifact.

Another way to save time is to measure only part of k-space and invoke its hermitian symmetry to calculate the unmeasured part. While this leaves resolution unaffected, it lowers the signal-to-noise ratio (MEZRICH 1995).

13.2.3
Needle Artifacts

Artifacts can be divided into those related to and those unrelated to the sequence and sequence parameters. System-dependent effects of field-strength differences or due to variation of needle orientation in relation to the main magnetic field $B_0$ have already been discussed in Chap. 5.

The material a needle is made of will influence the size of its artifact. To date, the commercially available MR-compatible needles have been constructed of different metal alloys, and before utilizing a particular brand, one should perform in vitro tests in order to determine the needle’s imaging characteristics for different sequences.