14.1 Introduction

Computed tomography fluoroscopy (CTF) is a technique that provides the physician immediate feedback via the reconstruction and display of CT images in real time and overcomes the classic limitations of ultrasound imaging and conventional fluoroscopy. It matches the advantages of CT quality images to be matched with the speed of fluoroscopic guidance. CTF images: (1) have a wide dynamic range for imaging air, soft tissue and bone, (2) do not superimpose anatomical structures in the same way as conventional fluoroscopy does, and (3) they provide acceptable image quality relatively unaffected by the patient’s breathing and motion (Kato et al. 1996; Froelich et al. 1998; Nickoloﬀ et al. 2000). These characteristics allow immediate correction for the depth and direction of a needle during a percutaneous procedure. The obvious beneﬁts of obtaining CT images in real time has made CTF a popular image guiding tool for various types of non-vascular and therapeutic interventions. Reported procedures using CTF guidance are, amongst others, precise needle placement, core biopsies, ﬂuid collection aspirations, catheter insertion and drainage, local drug injections, radiofrequency ablations, placement of marking coils before stereotactic radiotherapy, lumbar nerve root blocks, vertebroplasty, jejunostomy tube insertion, arthrodesis of the spine and arthrography. The term “ ﬂuoroscopy” in CTF is only used by analogy with its conventional radiology counterpart; the only common thing is that both techniques are based on X-ray imaging to give the impression of a real-time imaging display. In this paper, the use of real-time CT is referred to as CT fluoroscopy.
14.1.1 Radiation Risk

A drawback of CTF is the potential for significantly high patient and staff doses. This is reported by several authors and also by competent bodies such as UNSCEAR in their 2000 report and ICRP in their report “Managing patient dose in computed tomography” (ICRP 2000). The interventional nature of CTF requires specific radiation protection considerations compared to conventional CT.

First of all, the patient skin dose is of concern. Since the scanning plane is kept constant during the entire procedure, the same skin area is repeatedly exposed and cumulative patient skin doses can be substantial, which may reach deterministic thresholds for radiation injuries. Maximum patient skin dose is therefore the risk-related quantity of concern, rather than the effective dose received by the patient. Effective dose from CTF is usually in the same order of magnitude as doses from diagnostic CT scans due to the small patient volume irradiated. With CTF, the user can select high exposure settings in terms of high tube potentials (120 kVp) and high tube currents (90 mA). These are high values when compared to the exposure factors used in, for example, vascular interventional radiological (IR) procedures. This results in substantial skin dose rates. Also, prolonged CT scanning times can be necessary in cases of small lesions that are difficult to access.

In contrast to conventional CT where the operator is protected behind the lead screen of the console, CTF procedures require the presence of the staff in the examination room during CT scanning (Fig. 14.1). As a result, the operator is exposed to an intense scatter radiation field. For such IR procedures it is standard practice for the medical staff to protect themselves by wearing a lead apron. A lead apron efficiently shields most important organs, reducing the effective dose received by the individual. However, surface doses to the parts of the body that are not shielded by the apron can be substantial. These are in particular the doses to both hands and the dose to the head (eyes). Also, information about these doses is often unavailable, as they are not monitored routinely. The dose to the hands is of particular concern due to its proximity to the scanning plane, and although it is unacceptable and every effort must be made to keep the hands out of the primary beam, the risk exists and it has been reported (Fig. 14.2). A CT room is usually

![Fig. 14.1a,b. The presence of staff in the examination room during CT scanning can lead to their exposure to an intense scatter radiation field, especially of body parts not protected by the lead apron.](image)

![Fig. 14.2. The hand of the operator entering the primary beam during a CTF procedure](image)