2 Computed Tomography (CT) and CT Arthrography

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2.1 Introduction

Computed tomography (CT) and magnetic resonance (MR) imaging are now established methods of imaging investigation and both methods continue to develop. CT remains more suitable than MR in the assessment of acute trauma (e.g. acetabular fractures), but MR is considerably better for assessment of soft tissue injuries and tumours. The addition of arthrography further increases the specificity and sensitivity of both MR and CT for articular and acetabular labral lesions. CT remains essential in the assessment of patients in whom MR is contraindicated (e.g. due to intracranial aneurysm clips or cardiac pacemakers). CT therefore continues to have a role in the diagnosis and management of many pathologies of the pelvis and hips. Having decided that CT is an appropriate investigation for an individual, the precise format of the examination will depend upon the suspected pathology and the equipment available. This chapter describes recent developments in CT scanners, considerations for pelvic and hip CT scanning, dose reduction strategies, CT hip arthrography and CT guided intervention. The main aim is to outline those considerations that should optimise the images obtained, whilst minimising the radiation dose to the patient, whatever CT scanner is used.

2.2 Developments in CT

A CT image is a Cartesian co-ordinate map of normalised X-ray attenuation coefficients, generated by electronically filtered computerised back projection of X-ray transmission measurements in multiple directions through a section of the object in question. Those areas where recent developments have been made include helical scanning, multislice acquisition and real time CT “fluoroscopy” (Dawson and Lees 2001). These developments have been made on the back of improving technology which includes slip-rings for power and data transmission to and from the gantry, higher heat loading and more rapid heat dissipation X-ray tubes, high efficiency solid state X-ray detectors, faster data transmission and processing abilities of the electronics.
2.2.1 Slip Rings

The use of cables to supply power and take data from the rotating scanner gantry has now been superseded by slip rings. Replacing the cables with slip rings (large circumference electrically conducting rings) which encircle the X-ray tube path, and transferring power from the rings to the X-ray tube via conducting brushes on the X-ray tube gantry, allows the gantry to be continuously rotated in one direction. This has several advantages over the alternating wind up and unwind gantry rotation directions required by continuous cables. Rapid acceleration and deceleration of the gantry are no longer required yet a faster rotation speed can be achieved giving shorter scan acquisition times. The time delay between slices need be no longer than that required for table movement in conventional acquisition mode and the potential for acquiring continuously updated X-ray transmission data allows both helical scanning and CT fluoroscopy.

2.2.2 X-Ray Tubes

The development of slip rings resulted in a requirement for X-ray tubes to have both a higher heat capacity and a higher maximum tube current, as the mAs required for a single slice remained much the same but the time in which the slice was acquired was reduced. As an alternative to higher heat capacity, more rapid heat dissipation from the tube has been developed by one manufacturer. In addition, for helical scanning continuous X-ray output for up to 60 s may be required. The disadvantage of these X-ray tubes is the increased ease with which high radiation doses can be given to patients during CT investigations.

2.2.3 X-Ray Detectors

Xenon gas detectors, used in CT scanners for many years, have a conversion efficiency (X-rays to signal strength) of around 60%, which can diminish further if the detectors are not maintained. Solid state crystal detectors may have conversion efficiencies of nearly 100%, resulting in a 40% reduction in patient radiation dose for the equivalent scan appearances. The tendency for solid state detectors to continue emitting light after the X-rays had terminated (afterglow), and other technical problems with respect to the size of the front face of the individual detectors and the interspace material between adjacent detectors have been largely overcome.

The ease with which solid state detectors can be stacked in parallel adjacent channels has facilitated the development of multi-slice scanners. These scanners can acquire multiple sections simultaneously, which can be separately processed to give large numbers of thin sections, or recombined to give fewer thicker sections with lower noise.

2.2.4 Helical CT (Spiral or Volume Scanning)

The requirement for a break in the X-ray emission whilst the table is moved to the next slice position was overcome by the development of helical scanning. Helical scanning is performed by moving the table continuously during the exposure, from the first slice location to the last. Thus a helix of X-ray transmission data through the scan volume is acquired. To generate a CT image the data from adjacent turns of the helix are interpolated to produce transmission data which are effectively from a single slice location (Kalender et al. 1990). This process can be performed at any location within the helix, (except the first and last 180°’s – where there is no adjacent helix of data for interpolation). In this way overlapping slices can be produced without overlapping irradiation of the patient. The relationship between the X-ray fan beam collimation and the table movement per rotation of the gantry is called the pitch ratio. Extended or stretched pitch scans are performed with pitch ratios greater than 1. Such extended pitches can be used to trade off between greater scan volumes; shorter scan acquisition times and lower scan radiation doses. Stretching the pitch ratio to 1.25 has little effect on the image appearances, but pitch ratios greater than 1.5 produce images with effective slice thickness significantly greater than the nominal fan beam collimation thickness. Multislice scanners in particular may use pitch ratios of less than 1, this increases patient radiation dose and scan acquisition time but reduces image noise and some spiral scanner artefacts. By increasing the number of detector arrays (“multi-slice scanner”) several interlaced helices can be acquired simultaneously with the table increment per gantry rotation increased proportionately (McCollough and Zink 1999). Initial developments in multi-slice scanners