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PICTORIAL REVIEW

Orbital imaging: Part 1. Normal anatomy

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Advanced imaging techniques enable the radiologist to detect an increasing number of structures within the orbit not previously identifiable. We describe the imaging techniques and orbital anatomy with an emphasis on radiologically identifiable structures. In a second review of orbital pathology we present pathological processes that may involve these structures.

Introduction

The orbit is amenable to radiological investigation by several methods.[1,2] Multislice CT and MRI allow multiplanar imaging of both normal anatomy and pathology. Technical advances in MRI allow high-resolution imaging with visualization of small vessels and nerves within the orbit. As images become more refined, an understanding of this detailed anatomy will be increasingly necessary as the demand on radiology to diagnose smaller lesions increases. We provide a detailed account of orbital anatomy, with emphasis on structures visible on current imaging techniques. The anatomy of the globe is not considered in this paper.

Orbital technique

CT technique

The scan plane is planned from a lateral scout to be parallel to the infraorbital-meatal line approximating the orbital nerve plane. An example of an orbital protocol for spiral and multislice CT is given in Table 1. The protocol will differ according to indication. A 2.5–3 mm sectional thickness suffices for most imaging. Where small lesions, fractures or foreign bodies are being considered, the 2.5 mm axial images are reconstructed to 0.63 mm intervals. Slices 3 mm thick are preferred for routine soft tissue visualization on spiral CT because of the increased noise with thinner slices. Sections of 1.0 mm or 1.5 mm will be required for fractures or foreign bodies. Multiplanar reformatting enables further evaluation in the coronal and sagittal planes. Three-dimensional surface-shaded models may be produced when craniofacial surgery is planned providing eloquent demonstration of the bone anatomy in the context of fractures of the orbit and craniofacial abnormalities. The mA should be reduced to ensure the lowest ocular dose; we use an auto mA function to optimize image quality and dose. Increasing the noise index enables a reduction in mA at the expense of reduced signal to noise, but we have found the best compromise between signal to noise and dose to be at an index of 3.8. This usually produces an mAs of 160 that is comparable to a 150 mAs on the spiral scanner.

MR technique

The orbit can be imaged using a quadrangular routine head coil (for which we have provided a protocol: Table 2); however, better image quality can be achieved with a synergy head coil or even with surface coils. A synergy coil offers a combination of different quadrature or linear coils with each coil element independent of the other. The advantage is a larger area of coverage with the same signal to noise ratio (SNR). The aim is to

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Table 1 Imaging protocol: CT

CT	Multislice GE lightspeed 8 or 16	Spiral GE
KV	120	120
mA	Auto (limit 300 mA, noise index 3.8)	150
Slice thickness	2.5 mm	3 mm
Scan FOV	25 cm	25 cm
DFOV	15 cm	15 cm
Reconstruction mode	1i	N/a
Rotation time	0.8 s	1 s
Pitch ratio/pitch*	0.562:1	1.5*

N/a, not applicable.

Figure 1 The best quality on MR is achieved when synergy small loop coils are placed lateral to the orbit. This results in excellent signal intensity near the orbital apex and also allows the use of parallel imaging techniques.

obtain the highest possible spatial resolution without having signal drop-out near the midline or near the orbital apex. Both these locations constitute a challenge for imaging. The orbital apex requires a high spatial and contrast resolution, owing to the close approximation of the anatomical structures to each other and the optic canal and superior orbital fissure; moreover, the apex is often situated at the edge of the small surface coils where SNR is lower. SNR with small surface coils drops more at the deepest part (medial orbital wall) of the examined structure than when a single larger non-synergy coil is employed, and is also reduced by the square root of the SENSE (sensitivity encoding) factor used.

The highest spatial resolution is achieved with surface coils. In the past these were placed on the orbit like goggles, but this technique often resulted in loss of signal near the orbital apex. Today we place these coils on the lateral wall of the orbit on both sides (Fig. 1). In such a position they still provide enough signal near the orbital apex and they can serve as synergy coils.

Parallel imaging techniques such as SENSE can be used. Individual coil channels receive individual signals per coil element, which are combined in to one image. Unlike conventional phased array or synergy coil reconstructions, the coil elements cover the same anatomical area. Using two coil elements halves the number of phase encoding steps required to measure the same field of view (FOV). Thus one can acquire a higher spatial resolution in the same acquisition time or the same spatial resolution in half the time (when a SENSE factor 2 is used). Moreover, this coil positioning also allows the use of CLEAR (constant level appearance), automatically activated when SENSE is applied. CLEAR is part of SENSE functionality. It uses coil sensitivity maps provided by a reference scan to produce homogeneous signal intensity throughout the image, e.g. from the surface of the orbit to the midline and/or apex. With this technique high quality coronal T1-weighted images, 3.5 mm thick and with a matrix of 605×1024, can be made on a Phillips Intera 1.5T in 6 min 14 (TR = 600 ms, TE = 15 ms, FOV = 260 mm, RFOV = 65%, NSA = 3 with SENSE factor 2).

Fluid attenuated inversion recovery (FLAIR), short tau inversion recovery (STIR) and spectral fat saturated inversion or selective partial inversion recovery (SPIR) sequences are useful adjuncts to the orbital examination. STIR increases conspicuity of intraorbital pathology by nulling the hyperintensity of orbital fat. This is achieved by a 180°

Table 2 Standard imaging protocol: MRI (GE 1.5T Echospeed, version 8.2.3 software. GE Medical system Milwaukee, Wis)

MRI	Ax T1	Ax T2	Cor FS T2	Cor CE-T1	Ax Fs T1
TR	800	2800	4000–5000	800	800
TE	20	80	90	20	20
NEX	2	2	4	2	2
Matrix	256*192	256*192	384*256	256*192	256*192
FOV (cm)	16–20	20	16–20	16–20	16–20
Slice thickness (mm)	3	4	3	3	3
Gap	0.3	1.5	0	0.3	0.3
TI	-	-	-	-	