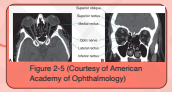
7.2.2. Evaluation of Orbital Disorders (II)

Ultrasonography

- B-scan ultrasonography
  - two-dimensional images
  - clinical uses
    - evaluating scleritis
      - fluid in the sub-Tenon space
    - localization of foreign bodies
- standardized A-scan ultrasonography
  - one-dimensional images
- doppler ultrasonography
  - arterialization
  - retrograde flow in the orbital veins
    - dural cavernous fistula
    - arteriovenous malformation
  - vascular abnormalities associated with increased blood flow
  - vascular tumors can be identified by
    - active pulsation
    - change in size with the Valsalva maneuver (compressibility)
- limitations
  - requires specialized equipment and experienced personnel
    - office-based equipment generally not suitable
  - limited value in assessing lesions of
    - posterior orbit
    - sinuses
    - intracranial space

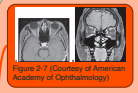
Computed Tomography

- each tissue has a density value
  - proportional to coefficient of absorption of x-rays
  - 2- or 3-dimensional images are digitally constructed from density measurements
- resolution and soft-tissue contrast of CT make it the most valuable technique for evaluation of orbital lesions
  - bone
  - soft tissue
  - foreign bodies
  - 
    Figure 2-5 (Courtesy of American Academy of Ophthalmology)
- bony resolution is superior to all other modalities
  - CT is the imaging technique of choice for orbital trauma and bony tumors
- 3-mm sections
  - for orbit
    - fine 1.5-mm cuts can be requested
- 5-mm sections
  - for head
- intravenous contrast-enhancing agent
  - tumors that are highly vascularized
    - meningioma
  - tumors that have altered vascular permeability
  - orbital abscess
- planes
  - axial plane
    - parallel to the course of the optic nerve
  - coronal plane
    - showing the eye, optic nerve, and extraocular muscles in cross section
  - sagittal plane
    - parallel to the nasal septum
- current CT scanners use software to reconstruct (reformat) any section in any direction
- spiral (helical) CT scanners
  - have multiple detector ports
  - scanner and collecting tube move in a spiral fashion around the patient
  - generate a continuous data set
    - allow rapid acquisition of a larger volume of data and highly detailed reconstructions
- direct coronal scans
  - ideal for evaluation of
    - optic nerve
    - extraocular muscles
    - bony roof and floor of the orbit
- three-dimensional CT
  - reformatting into 3-dimensional projections of the bony orbital walls
    - to assist in preparation for craniofacial surgery or repairs of complex orbital fractures
    -
      Figure 2-6 (Courtesy of American Academy of Ophthalmology)
  - requires thin sections
    - additional computer time

Comparison of CT and MRI

- contrast agents are available to improve CT and MRI detail
- CT is the single most-useful orbital imaging technique
  - faster
  - less expensive
  - less sensitive to movement artifact
  - provides better spatial resolution
    - precise localization
  - superior to MRI for the evaluation of
    - fractures
    - bone destruction
    - tissue calcification
  - in most orbital conditions, the orbital fat provides sufficient contrast to allow visualization of orbital tumors on CT
- MRI advantages over CT
  - better soft-tissue definition
    -
      Figure 2-8 (Courtesy of American Academy of Ophthalmology)
  - but
  - better tissue contrast
    - there is no artifact from the skull base bones
    - orbital apex
    - intracanalicular portion of the optic nerve
    - periorbital spaces
    - orbitocranial junction
      - orbitocranial tumors
    - brain
      - when the orbitocranial junction or brain is involved, CT scanning and MRI may be complementary
  - direct display of anatomical information in multiple planes
    - sagittal, axial, coronal, and any oblique plane
- MRI
- MRI is contraindicated in
  - ferromagnetic metallic foreign bodies in the orbit or periorbital soft tissue
    - presence of such foreign material can be ruled out with plain films or CT
  - ferromagnetic vascular clips
  - magnetic intravascular filters
  - electronic devices in the body
  - cardiac pacemakers
- dental amalgam
  - not ferromagnetic and not a contraindication to MRI
  - does produce artifacts and degrades the images on both MRI and CT
  - certain types of eye makeup can produce artifacts and should be removed
- bone and calcification produce low signal on MRI
  - bony structures may be evaluated by visualization of the signal void left by the bone
    - this is not possible when the bone is adjacent to structures that create a signal void
      - air
      - rapidly flowing blood
      - calcification
      - dura mater

Magnetic Resonance Imaging

- 
  Figure 2-7 (Courtesy of American Academy of Ophthalmology)
- does not employ ionizing radiation
  - no known adverse biological effects
- 3 physical components
  - atomic nuclei possessing an electrical charge
  - powerful magnetic field
  - radiofrequency (RF) waves
    - emitted from a coil lying within the magnetic field
- technique
  - tissue containing hydrogen atoms is placed in the magnetic field
  - individual nuclei align themselves in the direction of the magnetic field
  - aligned nuclei are excited by RF pulse
    - excited nuclei align themselves against the magnetic field
  - RF pulse is terminated
    - nuclei flip back to their original magnetized position
      - time it takes for this realignment to occur can be measured
        - relaxation time
- each orbital tissue has specific MR parameters
  - tissue proton density
    - number of protons per unit volume of tissue
    - fat has greater proton density than bone and, therefore, greater signal intensity
  - relaxation times
    - T1
      - longitudinal relaxation time
        - time required for the net bulk magnetization to realign itself along the original axis
        - T1-weighted images offer the best anatomical detail of the orbit
    - T2
      - transverse relaxation time
        - mean relaxation time based on the interaction of hydrogen nuclei within a given tissue
        - T2-weighted images have the advantage of showing methemoglobin brighter than melanin
          - these substances have the same signal intensity on T1-weighted images
          - difference in brightness seen on T2 images can be helpful in differentiating melanotic lesions from hemorrhagic processes
- gadolinium
  - paramagnetic contrast agent given intravenously
  - allows enhancement of vascularized lesions
    - exhibit same density as fat
  - enhancement of lesions with abnormal vascular permeability
- fat suppression
  - to suppress the normal bright signal of fat on T1 images
- FLAIR
  - fluid-attenuated inversion recovery
  - to suppress the bright signal of CSF on T2 images
- gradient echo sequences
  - reveal hemorrhage in vascular malformations
    - might be missed on T1- and T2-weighted images !

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