Ministry of Higher Education and Scientific Research
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Radiological Equipment Techniques

Al-Mustaqbal University College

3rd Class

Radiological Techniques Department

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Lecture 6: Images in MRI

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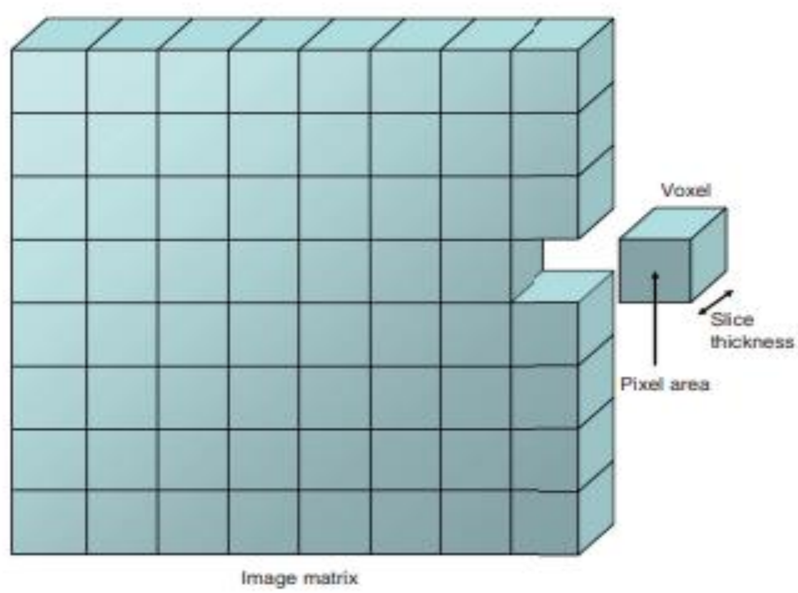
MR images are like photographs or plain digital X-radiographs; they are made up of thousands of tiny squares known as pixels (a contraction of 'picture elements') or voxels ('volume elements').

- A pixel represents the smallest sampled 2D element in an image. Pixel sizes range in clinical MRI from mm (e.g., $1 \times 1\ mm^2$) to sub-mm.
- A voxel is the volume element, defined in 3D space. Its dimensions are given by the pixel, together with the thickness of the slice (the measurement along the third axis).

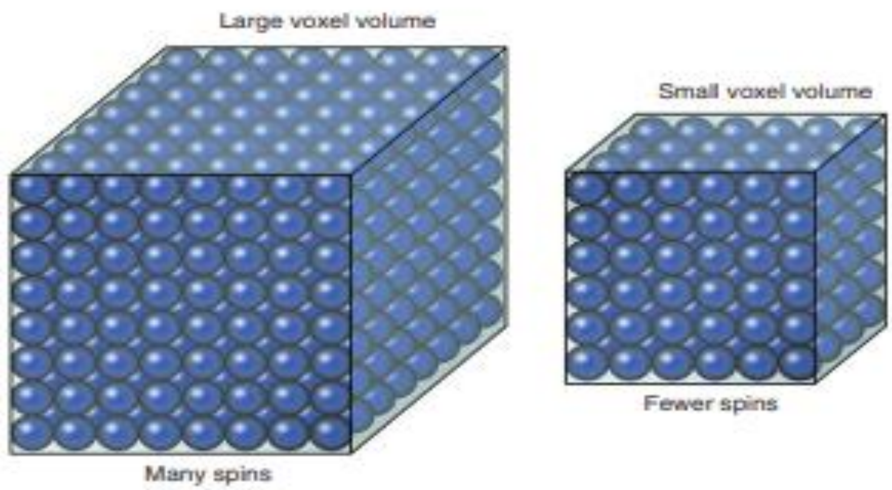
MRI spatial resolution, which determines the radiologist's ability to distinguish structures as separate and distinct from each other (together with image contrast), is inherently related to the acquired voxel volume.

The phase value can never be more than the frequency direction. It is important to understand that the image matrix describes only the number of pixels/voxel's in our image, not the size of our image (field of view).



The pixel size (FOV/matrix) determines the in-plane resolution. Reducing the FOV, increasing the matrix number, or reducing the slice thickness results in an image with reduced voxel volume.

- Large voxels contain more spins or nuclei than small voxels and therefore have more nuclei to contribute toward signal.

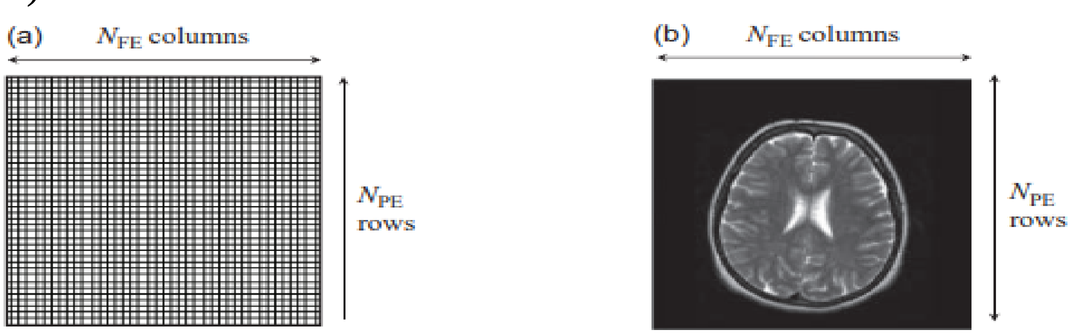


Large voxels consequently have a higher SNR than small voxels. SNR is therefore proportional to the voxel volume, and any parameter that alters the size of the voxel changes the SNR

Image Matrix

The image matrix is used to describe the tiny squares/ cubes (pixels/voxel's) of data found in our image.

The image matrix is conventionally shown in the following order: frequency-encode matrix, phase encode matrix, number of slices (for 3D scans).



Pixel size

We can calculate the size of our pixel by taking the field of view (FOV) and dividing it by the frequency/phase value

Pixel size = Field of view / Matrix size

Or

Pixel size= FOV/frequency/phase value

Example: Frequency=256, Phase=192, FOV=200

Field of View (FOV)

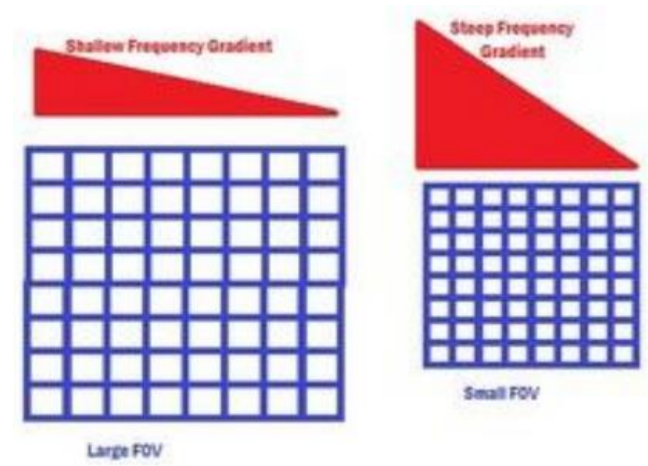
Generally, FOV is an operator-defined parameter that controls the apparent size of the patient in the image

- By making the FOV smaller, we will be squeezing our pixels in the image matrix forcing them to get smaller to fit the smaller FOV. This would increase our resolution.
- If we were to increase the FOV, we would force the pixels in our image matrix to expand to fit the larger FOV. This would decrease the image resolution

FOV and Frequency Encoding

FOV is controlled by the strength of the gradient coil in the frequency encoding direction of our K space.

- To achieve a small FOV in the frequency direction, a steep frequency-encoding gradient is applied. This will produce better image resolution
- To achieve a large FOV in the frequency direction, a shallow frequency-encoding gradient is applied. This will decreases the image resolution.

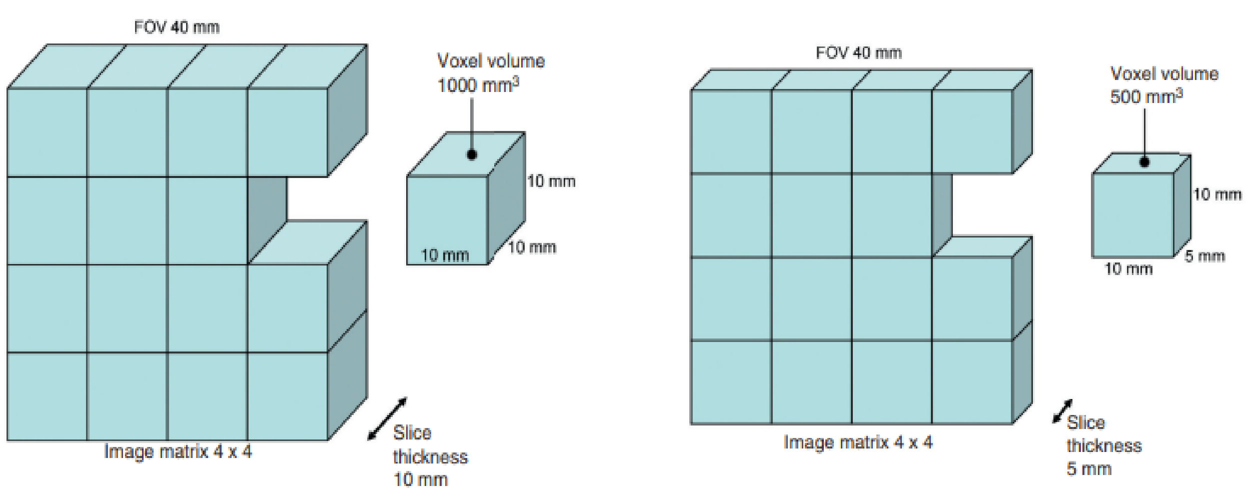


Signal-to-Noise Ratio (SNR)

as the name implies, a ratio of the signal received to the average amplitude of the noise in an acquired voxel.

SNR vs slice thickness

Changing the slice thickness. In Figure , voxel size is altered by halving the slice thickness from 10 to 5 mm. Doing so halves the voxel volume from 1000 to 500 mm^3 and hence halves the SNR.



Look at Figures 1 and 2 where the phase matrix increases from 128 (Figure 1) to 256 (Figure 1).

As the FOV remains unchanged, there are smaller pixels and therefore voxels in Figure 2 than in Figure 1. Therefore, as the voxel volume halves, the SNR also halves

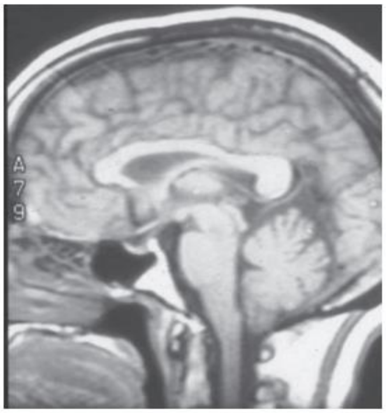


Figure (1) Sagittal brain using 128 phase matrix.

Figure (2) Sagittal brain using 256 phase matrix

SNR vs FOV.

The FOV halves, which halves the pixel dimension along both axes. Therefore, the voxel volume and SNR decrease to one quarter of the original value (from 1000 to 250 mm3). Comparing these Figure a and b, it is evident that SNR significantly decreases in figure b. Depending on the area under investigation and the receiver coil, it is sometimes necessary to take steps to increase SNR when using a small FOV especially in conjunction with a large coil.

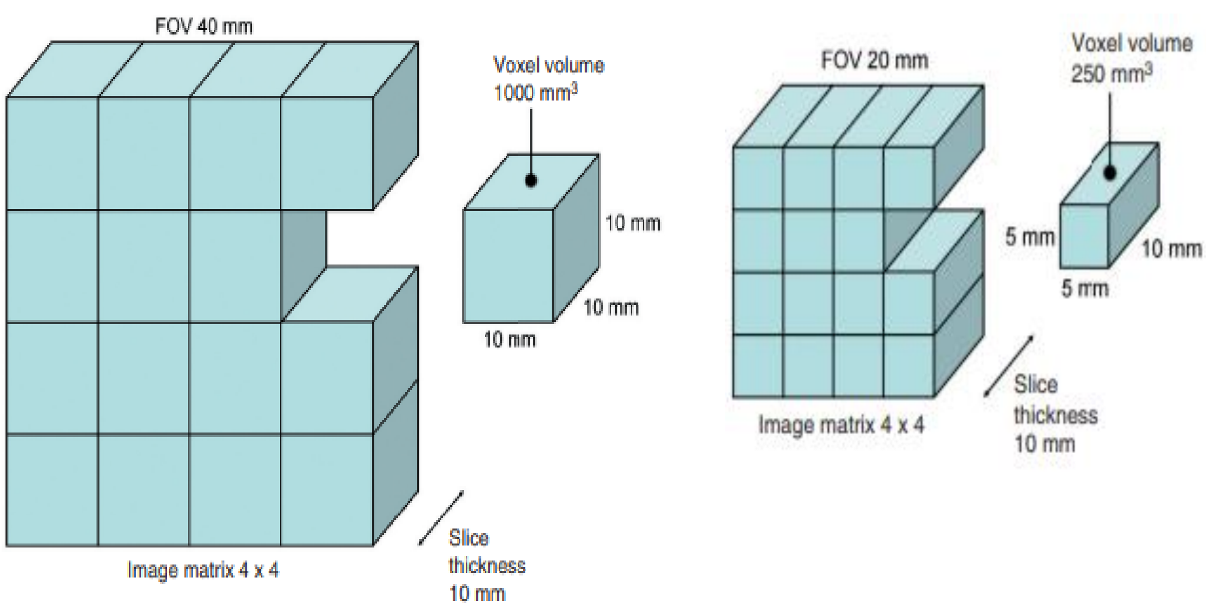


Figure (a) Sagittal brain using a square FOV of 240 mm.

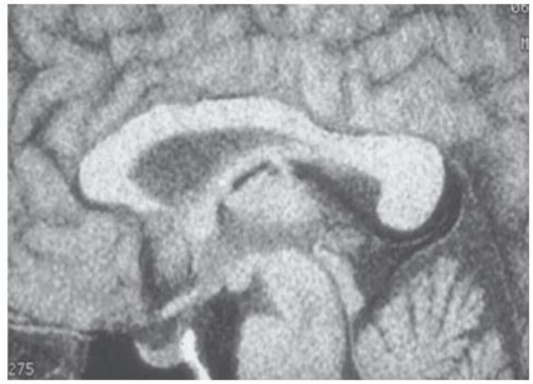


Figure (b) Sagittal brain using a square FOV of 120 mm.

Size of the (image) matrix

Another factor affecting signal to noise and contrast resolution is the voxel volume (3 dimensional volume of tissue). Spatial resolution corresponds to the size of the smallest detectable detail. The smaller the voxels are, the higher the potential spatial resolution will be.

Three parameters affect the Voxel volume (size of the voxel):
1- pixel size, which is established when the matrix size is chosen (256 × 256 or 512 × 512 etc...)
2- the field of view (area of interest) (10 cm, 20 cm, etc.... the small FOV is usually less than 18 cm and the large FOV is more than 30 cm), and
3-slice thickness.