IMAGE QUALITY

- Image Quality in MRI is a measure of the diagnostic accuracy and appearance of an image.
- It is defined by the contrast of the images, the ability to spatially resolve detail and the signal-to-noise ratio.

CONTRAST DISCRIMINATION

- Contrast is the difference in relative brightness between pixel values and is the result of the signal received from each voxel after scanning.
- The perception of contrast depends on the number of pixel intensities represented by each gray scale.
CONTRAST DISCRIMINATION

• Fourier transform separates the encoded signal into its individual frequency components.
• These signals are translated into a gray scale ranging between 256 shades of gray.

CONTRAST DISCRIMINATION

• Pixels with the most intense signal are assigned the highest value and are the brightest.
• Pixels with the lowest signal intensity are assigned the lowest value and are represented as the darkest.

FACTORS AFFECT CONTRAST

• TR, TE, ETE, ETL, TI
• Pulse Sequence
• Flip Angle
• Relaxation rates
• Hydrogen density
• Flow
• Contrast Media
**TIME OF REPETITION**

- TR is the time between successive RF pulses applied to the same slice.
- TR affects T1 contrast
  - short TR enhances T1 contrast
  - long TR minimizes T1 contrast

FSE: TR = 4500MS

FSE: TR = 6500MS
(TE) TIME TO ECHO

• TE is the time from the initial RF pulse to the middle of the listening window (echo).

• TE affects T2 contrast.
  • short TE minimizes T2 contrast
  • long TE enhances T2 contrast

SE: TE COMPARISON
(TI) TIME OF INVERSION

• TI is the time from the inverting pulse to the start of the 90° or partial RF pulse.
• TI affects T1 contrast.
  • short TI* minimizes T1 contrast
  • long TI* enhances T1 contrast

FSE: FSE - STIR

FSE: FSE - STIR
PULSE SEQUENCES

- Pulse sequences are a series of RF pulses and gradient applications in an event.
- Pulse sequences are chosen to enhance or accentuate specific tissue contrast.

- Spin Echo or FSE
  - T1, T2, PD
- Gradient Echo or FFE
  - T1, T2*, PD
- IR, STIR
  - T1, Fat Suppression
- FLAIR
  - Fluid Suppression

FLIP ANGLES

- Flip angles partially flip net longitudinal magnetization into the transverse plane.
- Lowering the flip angles flips less of net longitudinal magnetization into the transverse plane.
- Flip angles vary based on the type of contrast expected.
**CONTRAST PARAMETERS**

<table>
<thead>
<tr>
<th>Flip Angle</th>
<th>Contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>short</td>
<td>T2-wt.-like or T2*</td>
</tr>
<tr>
<td>medium</td>
<td>PD-wt.</td>
</tr>
<tr>
<td>long</td>
<td>T1-wt.</td>
</tr>
</tbody>
</table>

**RELAXATION TIMES**

- T1 relaxation times are dependent on the field strength of the magnet.
  - As field strength increases, T1 lengthens.
- T2 relaxation times do not change significantly with magnetic field strength but do change based on chemical and molecular bonding.

**RELAXATION TIMES**

- Hydrogen Density is the number of hydrogen atoms present in the tissue.
- Hydrogen Density is one of the major determinants of tissue contrast.
- Flow refers to hydrogen in motion during the acquisition. Imaging techniques cause different appearances of flowing spins.
- Contrast Media shortens the T1 & T2 relaxation times of tissues causing a change in contrast.
SPATIAL RESOLUTION

• Is the ability to distinguish or represent small objects defining the sharpness of an image.
• Spatial resolution is controlled by parameters that affect the amount of tissue or signal represented by the pixel or voxel.
• Images have three dimensions:
  • length and width: pixel size or resolution
  • depth: slice thickness

SPATIAL RESOLUTION FACTORS

• Factors that affect Spatial Resolution
  • voxel size
  • pixel size
  • slice thickness
  • matrix size
  • field of view (FOV)

SPATIAL RESOLUTION

• Anything that makes a geometric change in the size of the image will affect spatial resolution.
SPATIAL RESOLUTION FACTORS

- **Voxel Size**
  - Voxels are three-dimensional volume elements.
  - pixel resolution x slice thickness = voxel size.

- **Pixel Size**
  - Pixels are two-dimensional picture elements.
  - pixels have length and width.
  - Decreasing the voxel or pixel size increases resolution.

SLICE THICKNESS

- **Slice thickness**
  - As the slice thickness changes so does the amount of information collected within the voxel.
  - The smaller the amount collected the more accurately the pixel is able to represent the information contained in the image.

FSE: TE/Slice Thickness
**MATRIX SIZE**

- Matrix size defines the length and width of the imaged area and is comprised of pixels.
- Matrix is selected by the number of phase encoding and frequency encoding steps used to create the image.
- The more steps and the smaller each step the better the spatial resolution.

**FIELD OF VIEW (FOV)**

- Field of View (FOV)
  - Field of view is defined as the area of interest demonstrated on the image.
  - Field of view is comprised of a matrix with a particular number of pixels and each pixel a specific slice thickness - voxels
  - The smaller the FOV the better the spatial resolution.
  - FOV = Matrix x Resolution (pixel)

**SIGNAL-TO-NOISE RATIO**

- Signal-to-noise ratio is used to describe the relative contributions to a detected signal made by the true signal and by random superimposed signals or noise.
- As the signal strength increases the signal-to-noise ratio increases and better image quality results.
SIGNAL-TO-NOISE RATIO

- Noise superimposed on the signal causes the pixel values to oscillate about a mean value.
- Noise blurs the edges of the tissue interfaces reducing edge acuity.
- Noise is created either by the tissues (non-hydrogen substances) or by the imaging system.

SIGNAL-TO-NOISE RATIO FACTORS

- These factors affect signal-to-noise-ratio
  - proton density
  - field homogeneity
  - voxel volume
  - slice thickness, gap
  - TR, TE, TI
  - NEX
  - Field of View

TIME OF REPETITION (TR)

- TR
  - Lengthening the TR allows more time for the tissues to return signal after being disturbed by the RF pulse.
  - Signal-to-noise ratio is increased with increase in TR.
TIME TO ECHO (TE)

- TE
  - The longer the TE the more T2 relaxation has occurred and
    the more decay of the transverse magnetization.
  - Increasing TE will decrease the S/N ratio.

NUMBER OF EXCITATIONS (NEX)

- NEX
  - The number of times the information is collected and
    averaged to create the image, the higher the signal-to-
    noise ratio.
  - This is also referred to as the number of acquisitions or signal
    averages.
  - S/N ratio will be improved by the square root of two, when
doubling the NEX which is a 41% increase in signal-to-noise.
MATRIX SIZE

- Matrix Size
  - Most matrix size adjustments require that either the pixel size or resolution also change to maintain, decrease, or increase the FOV.
  - Overall, there may be an increased S/N ratio by the sheer fact that the more number of lines within the matrix requires additional phase encoding steps which will increase S/N ratio.

FIELD OF VIEW (FOV)

- Field of View (FOV)
  - The relationship between the matrix and the FOV has a definite impact on the signal-to-noise ratio by determining the size of the pixels represented in the matrix.
  - Usually when the FOV is decreased while maintaining the matrix size, the pixels decrease in size decreasing S/N.

RECEIVER BANDWIDTH

- The receiver bandwidth is the range of frequencies received during the acquisition.
  - In general, the narrower the bandwidth, the higher the signal-to-noise ratio.
RECEIVER BANDWIDTH

- The range can be varied in several ways:
  - sampling the same number of data points over a shorter/longer listening window,
  - changing the number of samples or data points while maintaining the listening window,
  - increasing or decreasing the amplitude of the readout gradient.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Benefit</th>
<th>Limitation</th>
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</thead>
<tbody>
<tr>
<td>TR increased</td>
<td>Increased SNR</td>
<td>Decreased number of slices</td>
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<tr>
<td>TR decreased</td>
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<tr>
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</tr>
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<td>Receive bandwidth decreased</td>
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<tr>
<td>Length of coil</td>
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<tr>
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40 Parameters and Trade-offs

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