OPTIMAZITION OF PROTOCALS IN MAGNETIC RESONANCE IMAGING (MRI)

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ABSTRACT

Background: One of the main advantages of MRI is the excellent soft tissue discrimination in the images. The contrast characteristics of each image depend on many variables, and it is important that the mechanisms that effect image contrast in MRI are understood. **Aim:** To optimize or formulate a specific set of sequences in MRI protocol for both routine and special cases. **Objectives: (i)** To standardize the MRI protocols. (ii) These protocols may be used for all the centres. (iii) In the absence of radiologist, Technologist will be able to perform the study according to the clinical history of the patients. (iv) It can be better utilized by students of Medical Imaging Technology. (v) Diagnostic accuracy can be made consistent. **Recent findings:** Studies of diverse populations demonstrate the link between general protocol and optimizes protocol to save the time. **Methods:** 10 adult cases of each study from the patients in the department of Radiodiagnosis and medical Imaging, Justice K. S. Hegde Hospital, Mangalore, Karnataka, India. **Conclusion:** This study show that applied moshed of advanced protocols of magnetic resonance imaging can save the time and as well as improved the quality of magnetic resonance imaging images, it also helps the Radiologist for reporting because there will be some less images and save their time, this saved time can be used for another ill patients those who need it. Protocol optimization would have to be performed on a per scanner and per protocol basis. Proper optimization might make accurate aortic flow quantification possible for most scanners.

CHAPTER I

1.1 Aim

To optimize or formulate a specific set of sequences in MRI protocol for both routine and special cases.

1.2 Objective

- To standardise the MRI protocols.
- These protocols may be used for all the centres.
- In the absence of radiologist, Technologist will be able to perform the study according to the clinical history of the patients.
- It can be better utilized by students of Medical Imaging Technology.
- Diagnostic accuracy can be made consistent.

1.3 Introduction to MRI

One of the main advantages of MRI is the excellent soft tissue discrimination in the images. The contrast characteristics of each image depend on many variables, and it is important that the mechanisms that effect image contrast in MRI are understood.

1.4 What MRI does?

When the patient is placed in the strong magnetic field of the MRI scanner, the hydrogen nuclei in the body align with the applied external magnetic field when exposed to short burst of the electromagnetic energy in the form of radio-frequency [RF] pulses. The hydrogen nuclei in the patient's body absorb its energy and then generate MR signal. This process of exchanging energy is done due to the phenomenon known as resonance. It forms the basics of MR imaging.

1.5 Common contraindications of MRI

- Cardiac face maker.
- Metallic fragments.
- Metallic device in brain, eyes, spinal canal.
- Local sepsis.
- Claustrophobic patients (open MRI may be suggested).
- Allergy to gadolinium (only in case of contrast study).

1.6 Common patient preparations for MRI

- Complete removal of jewelry's, body piercing and hair clips are mandatory.

- Bring reports and images of previous studies done of same area being examined.
- Carry out blood investigation for urea & creatinine.
- Obtain the patient's weight.
- Nicotine patch must be removed
- Written Informed consent.
- Inform the patient about the procedure and duration of exam.

1.7 MR safety
Certain facts should be taken care to avoid any kind of accidents due to the strong magnetic field or electric shock generated due to the magnetic field.

MR safe
MR safe means that an object or device, which is safe in the magnetic field up to certain strength. Beyond that, it will be influenced by the magnet.
E.g.: - MR safe for 1.5T - Up to 1.5T it is safe but cannot be used in 3T.

MR compatible
MR compatible means that an object or device, which is safe in all the magnetic fields regardless the strength of the magnet.
E.g.: - MR compatible trolley or wheel chair.

1.8 Image Weighting and Contrast
T1 contrast
- The T1 time of fat is shorter than water, the fat vector realigns with B_o faster than that of water.
- As there is more longitudinal magnetization in fat before the RF pulse, there is more transverse magnetization in fat after the RF pulse. Fat therefore a high signal and appear bright on a T1 contrast images.
- The T2 time of fat is shorter than that of water, therefore the transverse component of magnetization of fat decays faster. The magnitude of transverse magnetization in water is large. Water has a high signal and appears bright on T2 contrast images.

T2 contrast
- The T2 time of fat is shorter than that of water, therefore the transverse component of magnetization of fat decays faster. The magnitude of transverse magnetization in water is large. Water has a high signal and appears bright on T2 contrast images.

Proton density contrast
- Proton density contrast refers to differences in signal intensity between tissues which are a consequence of their relative number of protons per unit volume.
- Proton density contrast is always present and depends on the patient and the area being examined. It is the basic MRI contrast.
- Fat has a short T1& T2 time
- Water has a long T1 & T2 time.

- To produce the high signal, there must be a large component of magnetization in the transverse plane to include a large signal in the coil.
- To produce a low signal, there must be small component of magnetization in transverse to include a small signal in the coil.
- T1 weighted images are characterized by bright fat and dark water.
- T2 weighted images are characterized by bright water and dark fat.

Proton density weighted images are characterized by
- Areas with high proton density are bright,
- Areas with low proton density are dark.

Weighting
To demonstrate either T1 proton density or T2 contrast, specific values of TR and TE are selected for a given pulse sequence. The selection of appropriate TR and TE weights an image so that one contrast mechanism predominates over the two.

T1 weighting
- A T1 weighed image is one where the contrast pronominally on the differences in the T1 times between fat and water.
- Because the TR controls low for each vector can recover before it is excited by the next RF pulse to achieve T1 weighting the TR must be short enough so that neither fat nor water has sufficient time to fully return to B0.
- TR controls the amount of T1 weighting.
- For T1 weighting TR must be short.

T2 weighting
- A T2 weighting image one where the contrast predominantly depends on the differences in the T2 times between fat and water.
- The TE contrast the amount of T2 decay that is allowed be occur before the signal received, to achieve T2 weighting, the TE must be long enough to give both fat and water time to decay.
- TE controls the amount of T2 weighting.
- For T2 weighting the TE must be long.

1.9 Some important parameters
➢ Antero-posterior [AP]:- from the front to the back
➢ Postero-Anterior [PA]:-From back to the front
➢ From head to foot [HF]
➢ From foot to head [FH]
➢ Constructive interference steady state [CISS]:-A sequence which supposedly minimizes the interference-induced artefacts of a true FISP sequence.
➢ Coronal Frontal: -A plane made by cutting across the body from side to side (left to right or right to left)
➢ Cerebrospinal fluid [CSF]:-Dark fluid Turbo inversion recovery sequence.

- Dual echo steady state [DESS]:- gradient echo sequence where both axial and transverse magnetization adds to the signal.
- Fast field echo [FFE]
- Fast imaging with steady state [FISP]
- Gradient echo [GRE]
- Gradient recalled acquisition of steady state [GRASS]:- gradient echo imaging where axial and transverse magnetization is combined and the contrast is the ratio of T1 to T2FH From feet to head
- Fast imaging with steady state [FISP].
- Fluid attenuated inversion recovery [FLAIR]
- Fast low angle shot [FLASH]
- Gd-BOPTA: - Gadobenatedimeglumine, Multi Hence
- Gd-DTPA Gadolinium diethylenetriamine Penta acetic acid Complex, a gadolinium chelate; a contrast agent, such as Magnevist, which shortens T1.
- Gradient-recalled acquisition of steady state [GRASS]
- Half-Fourier acquisition single-shot turbo spin echo [HASTE].
- Inversion recovery [IR]:- a pulse sequence where the magnetization is inverted by a 180° pulse before the excitation pulses for signal acquisition are started.
- Maximum intensity projection [MIP]:- An image processing method where all high-intensity signals are filtered and projected in one plane Medial-sagittal.
- Motion artefact suppression: A method of suppressing motion artefacts.
- Magnetic resonance angiography [MRA].
- Magnetic resonance imaging [MRI].
- Number of excitations [NEX].
- Number of signal averages [NSA]:-NEX, how often a sequence is repeated; repetition improves the signal-to-noise ratio and thus image quality.
- Orientation: -Spatial arrangement of the slices
- Gradient: Fold over direction: there are fold over artefacts' (aliasing) as well as pulsation artefacts along the direction of the phase-encoding gradient.
- Phase contrast angiography: -The changes in the phase shifts of the flowing protons in the region of interest are used to create an image.
- Refocused acquisition in readout direction [RARE].
- Reticule-endothelial system of the liver [RES]: - which takes ferruginous contrast agents.
- Respiration triggering: -Data acquisition takes place only during one particular phase of the respiration cycle [inspiration or expiration]. Usually, the sensor is housed in a strap around the chest.
- Signal to noise ratio [SNR]:-The ratio of the signal acquired to the back ground noise: the higher the number, the better the image.
- Slab thickness: Thickness of a volume excited during 3-D imaging.
- Slice gap:-The gap between two slices, [for a slice thickness of 8 mm this means a gap of 0.8 mm].

- Spectral pre-saturation with inversion recovery [SPIR]:-fat suppression where the fat signal is excited by frequency selective saturation.
- Short TI inversion recovery [STIR]:- Inversion recovery pulse sequence with short TI for fat suppression. All signals with short T1 times similar to that of fat will be suppressed and usually they will not be displayed after contrast administration.
- Echo time [TE]: the time between the excitation and the middle of the readout process.
- TE shortest: -The scanner automatically selects the shortest TE possible.
- Tesla: -The unit of magnetic field strength (magnetic flux density). Named after Nikolaou Tesla, a nineteenth century Croatian engineer.
- TI Inversion time: in inversion recovery sequences, the time between the inversion pulse and the 90° pulse.
- Turbo inversion recovery measurement [TIRM].
- Time of flight [TOF]:- measurement method used in MR angiography. Unsaturated spins flow into a magnetized pre-saturated sample volume, and the differences between the unsaturated and prostrated spins aroused to create the image.
- TR Repetition time: the time between successive pulse sequences.

1.10 Parameters for various field strengths

- T1-weighted: -The correlation between T1 and field strength is weak: TR for1.5 T is the same as or slightly longer than TR for 0.5 T.
- TE:-For the most part TE depends on the strength of the gradient. Most units with greater field strength also have a greater gradient strength. Thus, for example, TE (1.5 T): 12 ms; TE (1.0 T): 16 ms; TE (0.5 T): 24 ms.
- T2-weighted: T2 is almost completely independent of the field strength. TR for 1.5 T corresponds to TR for 0.5 T.
- Echo time in phase and out of phase: The echo times in phase and out of phase depend on the field strength:
- Echo times in phase are even multiples and those out of phase are odd multiples of 6.9ms for 0.5 T,3.45ms for 1.0 T& 2.3ms for 1.5 T.

Phase-encoding gradient
Usually the phase-encoding gradient employed is: -For sagittal images: PA, for axial images: PA & for coronal images:

Flip angle
For SE and TSE sequences the flip angle usually is 90° or 180°. Slice.

Sequence
Most often the slice sequence is set as interleaved; otherwise, the slice gap is1.2.
TR Repetition time: the time between successive pulse sequences.

2 METHODOLOGY

2.1 Material & Methods

This study is a hospital based prospective study carried out over of six months, The study was carried out in the department of Radiodiagnosis and Imaging at, Justice K. S. Hegde Hospital, Mangalore, Karnataka, India, This Data collected during study period of B.Sc. Medical Imaging Technology for study purpose.

10 adult cases of each study from the patients in the department of Radiodiagnosis and medical Imaging, Justice K. S. Hegde Hospital, Mangalore, Karnataka, India.

After taking informed consent, collection of data in a structured proforma from patient record file such as age, gender, height, Body Mass Index (BMI) and brief, relevant clinical details were recorded. Collection of such information from the patient or their relatives was done if any relevant information were missing in the patient's record file. Measurement of the height and weight for the calculation of the BMI of the patient were also done in those cases where it was not provided.

MRI were done with initial few cases on the GE 0.5T machine and remaining all the cases on the GE 1.5TMRI scan machine.

The data were entered in the MS excel 2019 and converted into SPSS 11.5 for statistical analysis. For descriptive statistics, frequency, percentage, Mean and SD were used along with graphical and tabular presentation. Analyses tests used in this study were independent samples t-test, paired sample t-test, and Pearson's correlation. A p-value <0.05 were considered statistically significant.

2.2 Research design

Descriptive cross sectional study design was used for this study.

2.3 Study Setting

The study setting was Department of Radiodiagnosis of Imaging at Justice K. S. Hegde Hospital, Mangalore, Karnataka, India.

2.4 Study population

This study was conducted among patients with those are coming for Magnetic Resonance Imaging Scan in the Department of Radiodiagnosis of Imaging at Justice K. S. Hegde Hospital, Mangalore, Karnataka, India was population for this study.

2.5 Sample size

10 adult cases of each study from the patients in the department of Radiodiagnosis and medical Imaging, Justice K. S. Hegde Hospital, Mangalore, Karnataka, India.

Calculation of the sample size sample size was calculated for this study as considering confidence interval 95%, allowable error 10%. Sample size is calculated by applying following formula:

2.6 Sampling technique

Non probability convenient sampling technique was used for the study.

2.7 Study duration

Mentioned on work plan Total study duration was 6 months and data collection period were 7weeks.

2.8 Inclusion criteria

- Patients without any other diseases or abnormalities.
- Patients who are well cooperative to the study.
- The scans without any errors in the technical aspects and positioning.
- Satisfactory results will be selected after discussing with radiologists and other physicians.

2.9 Exclusion criteria

- Patients with cardiac Pace maker, Orthopedic fixator or other implants.
- Non-cooperative patients.
- Non-satisfactory results.
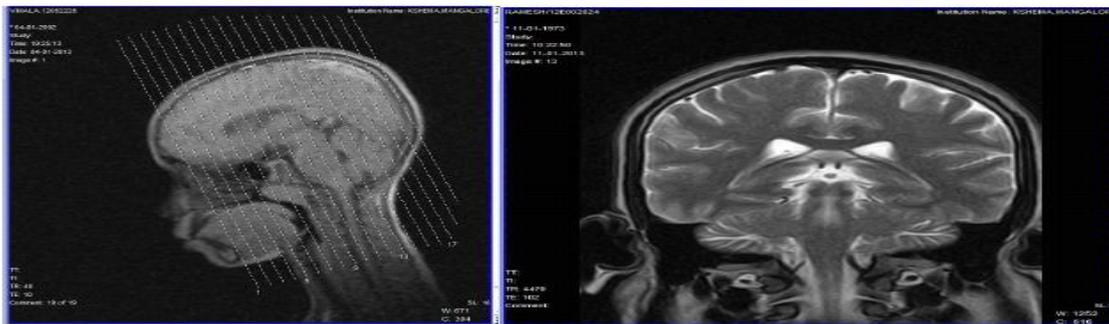
2.10 Statistical methods applied

Data was analyzed using statistical package for social sciences (SPSS) version 20.0. Descriptive statistics like percentage, frequency, mean and standard deviation were applied to describe independent variables. For inferential statistics chi square was applied to find association between awareness and sociodemographic variables and health status and health related behavior.

2.11 Ethical clearance

Ethical principles have been considered and followed throughout the study. Informed written consent was obtained from each participant. Confidentiality of the subject was maintained and obtained data was used only for research purpose. Privacy was maintained by collecting data in separate room.

3   Imaging of magnetic resonance imagings
3.1 Brain
Anatomy of brain

Practical MRI imaging
Brain
Indications
- Evaluation of infraction, AIDS.
- Multiple sclerosis, primary tumor assessment and metastatic disease.
- Unexplained neurological symptoms or deficit.
- Trauma.
- Chronic headache.
- Post & pre-operative cases.
- Stroke.

Contraindications
- All common contraindications of MRI.

Patient preparation
- All common patient preparation.

Position of Patient & Coil
- Patient position –Head coil.
- Set up the head coil.

- Place the patient in the head coil.
- Immobilize the patient using sponges and straps.

Protocol
Flair
- Fluid attenuated inversion recovery (FLAIR) MR imaging technique where first describe by Hajnal etal.
- In all IR sequence if the inversion time (T1) in increased to 1500-2000 msec the longitudinal magnetization of the brain is almost fully recovered.
- The signal from the CSF can be hulled.

Planning: - Coverage should be from cortex down to base of skull
- Sagittal section.
- Axial images are used to plan for sagittal section. Then adjustments are done on the coronal image also.

- Coronal section.

- Sagittal images are used to plan for sagittal section. Then adjustments are done on the axial image also.

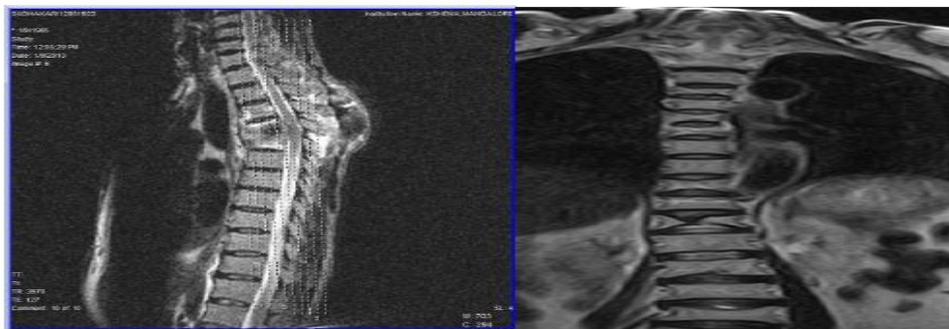- Axial section.
- Sagittal images are used to plan for sagittal section. Then adjustments are done on the Coronal image also.
- The FLAIR sequence is used in heavily T2 weighted form in the brain where most lesions are highlighted. It also can be used to improve the accuracy of detecting T2 prolongation in the hippocampus in mesicalt emporal sclerosis.
- The main disadvantage of FLAIR MRI is long acquisition times.
- FLAIR technique is currently used in a variety of brain disease hemorrhage, trauma, cystic lesions, tumors' polycystic astrocytoma, glioblastoma and vascular malformation.

Routine protocols
- T2 FLAIR
- T1 FLAIR
- T2 CORONAL
- T2 SAGITTAL.
- T1 SAGITTAL.
- T2 AXIAL.

Post contrast
- T1 SAG.
- T1 COR.
- T1 AXIAL

Special protocols
- FLAIR.
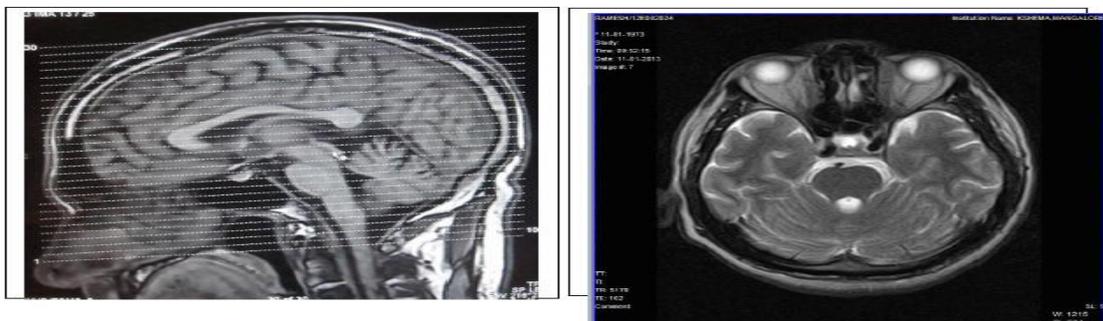
Stroke
- GRE, T2, SWI

Epilapsy
- FLAIR

- GPGR

Infact
DWI
SEIZURE; -

T2 SAG TSE   T2 COR STIR.
T1 AXIAL TSE

3.2 Cervical spine [C. Spine]
Anatomy of C. spine
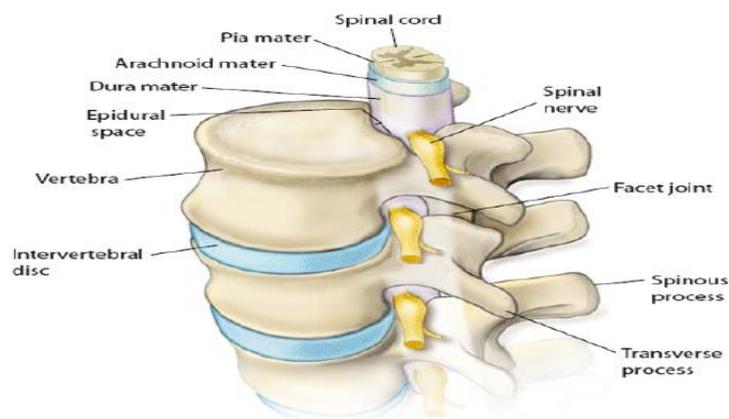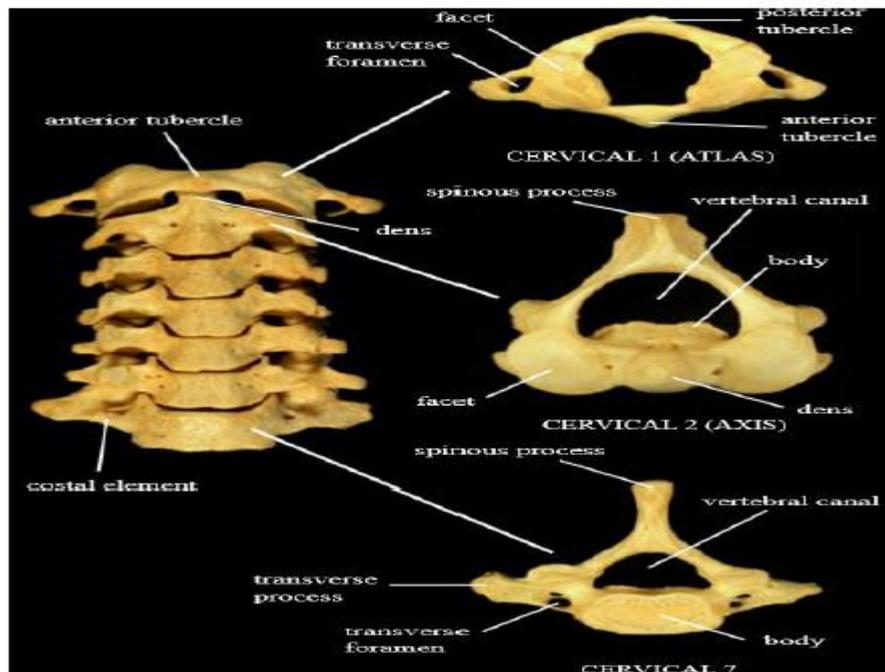
Indication
- Cervical myelopathy.
- Cervical cord compression or trauma.
- Assessment of extent of spinal infection or tumors.
- Diagnosis of chair: Malformation (Whole spine imaging may be necessary)
- Visualization of MS (Multiple Sclerosis or Lesion) plaques within the cord.

Contraindication
- All common contraindications

Patient preparations
- All common patient preparations

Position the Patient and Coils
- Position of the patient is supine, head first on the table.
- Place the coil on the magnet table and plug it.
- Place patient supine, head first. Rest the head and neck in the coil.
- Position the superior end of the coil at the base of the skull. This position should include C1 on a sagittal image so that you can count vertebra for localization purpose.

Planning for cervical spine: - Coverage should be from TMJ down to T1 vertebrae
- Axial section.

- Sagittal images are used to plan for sagittal section. Then adjustments are done on the Coronal image also.

- Sagittal section.

- Coronal images are used to plan for sagittal section. Then adjustments are done on the Coronal image also.
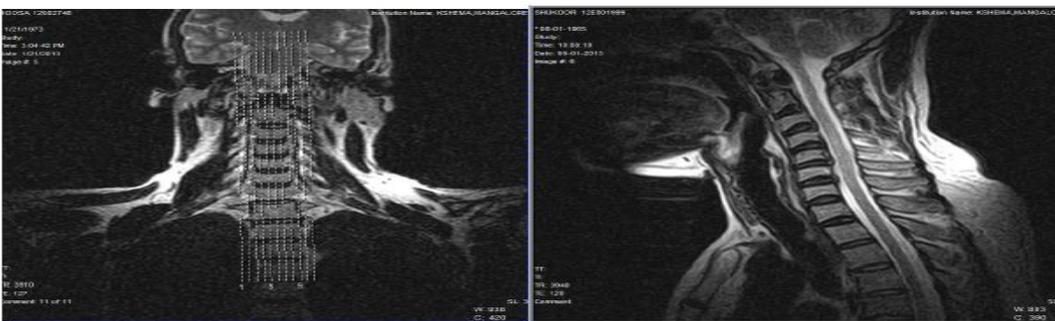

Protocols of cervical spine
Routine
- T1SE Sag.
- T2FSE Sag.
- 3D Volumetric axial T2* GRE.
- Axial T1SE.

Special
- Axial T2 TSE (Target axial to abnormalities).

Trauma
- Sag FSE-IR (Turbo-IR).
- Axial T2 FSE with fat sag.
- 2D FLASH axial/ sag.

Post-operative cervical spine MRI
T1 SE Sag
T2 FSE Sag
T2 axial 3D (T2* GRE)
Note: -IV contrast only required for tumor/demyelinising diseases.

- Coronal sections.
- Sagittal images are used to plan for sagittal section. Then adjustments are done on the Coronal image also.
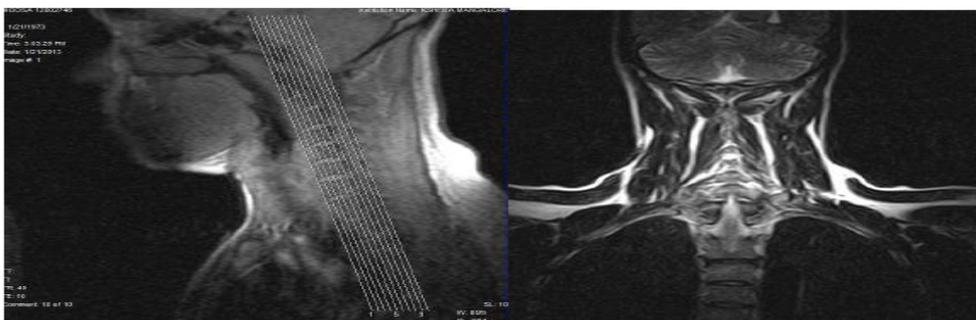
- Axial [trufi] section.

- Coronal images are used to plan for axial section. Then adjustments are done on the sagittal image also.
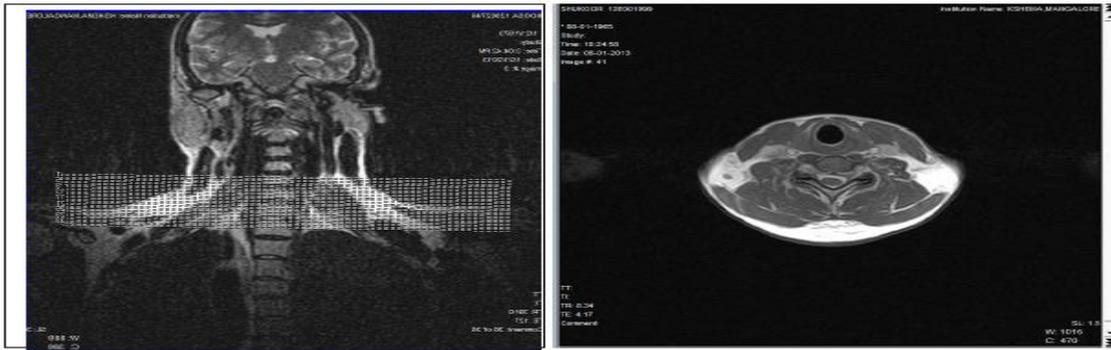
3.3 Thoracic spine [D. Spine or T. Spine]
Anatomy of T. spine

6th thoracic vertebra
(superior view)

6th thoracic vertebra
(lateral view)

The Thoracic Spine
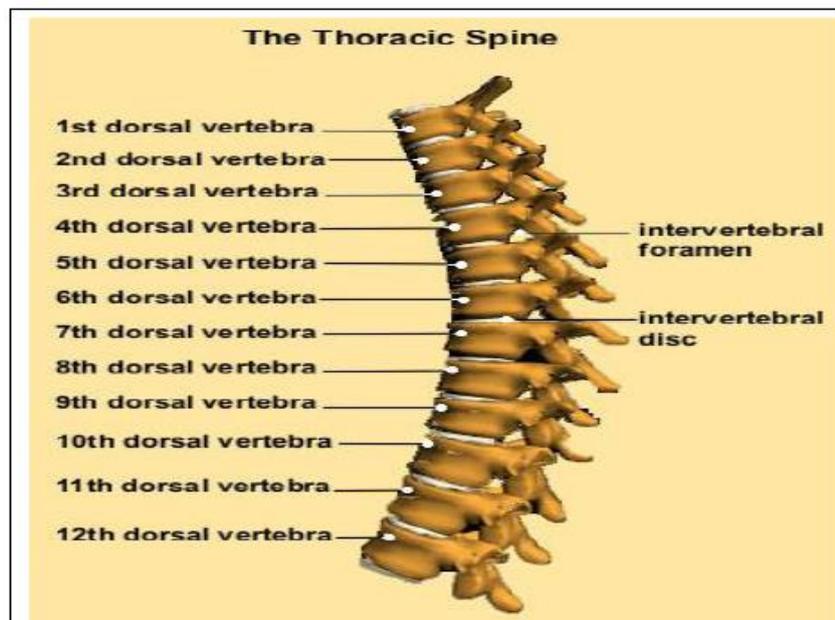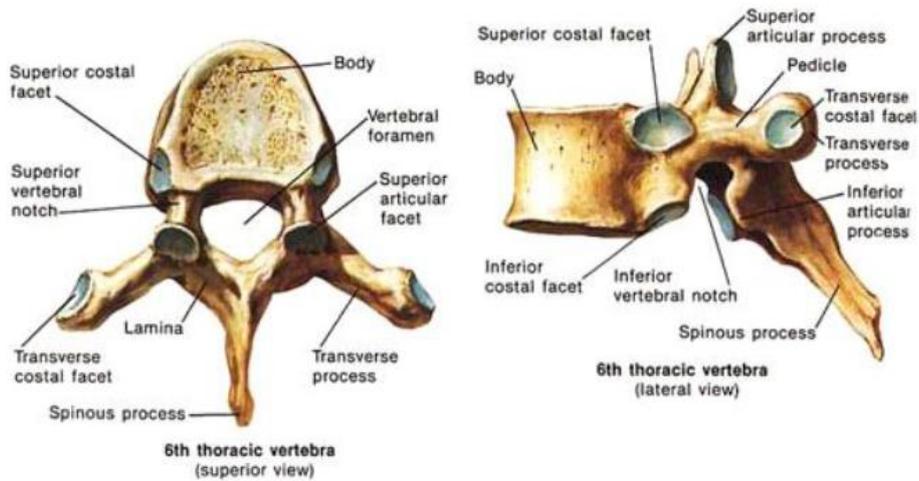
Indication
- Thoracic disc disease (Benign and Malignant)
- Thoracic disc compression
- MS (Multiple Sclerosis).
- To visualize the inferior extent of cervical shrine.

Contraindication
- All common contraindications

Patient preparation for T-Spine
- All common patient preparations

Position of Patient and Coil
- Patient position- phased array coil CTL Mid.
- Place the phased array coil on the magnet table and plug the phased array coil port.
- Position patient supine and either head or feet first. A feet first position may be preferred for claustrophobic patients.
- Place arms at the slides or above the head, whichever is most comfortable for the patient. If you are using the gating option, place the arms by the sides to keep good blood flow to the fingers. Attach the P-gating device.
- Using accessories such as the knee booster and blankets to make the patient as comfortable as possible.

- Locate T1 through T12 on the patient and determine which coils will best cover the whole spine (Ex. CTL Bottom).
- Place the axial alignment light 2cm above the xiphoid which is approximately T7 press landmark.
- Explicitly instructs the patient not to move during the scan e.g. don't shift hips or move legs.

Planning for thoracic spine: - Coverage should be from C1 vertebrae down to L1 vertebrae sufficient to include all nerve roots
- Axial section.
- Sagittal images are used to plan for axial section. Then adjustments are done on the Coronal image also.
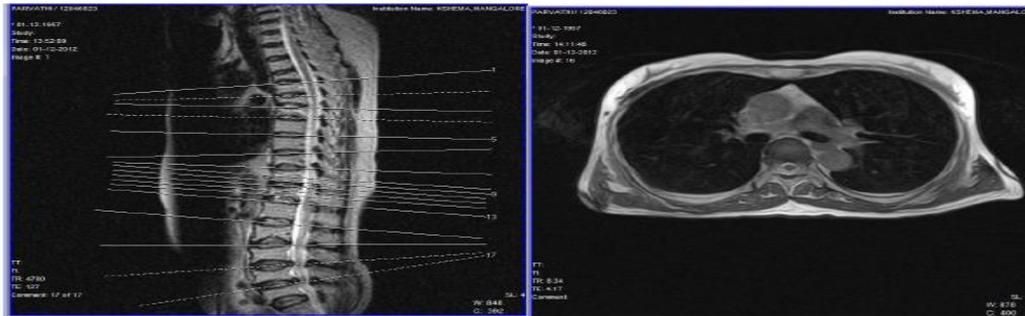
- Coronal section.

- Sagittal images are used to plan for coronal section. Then adjustments are done on the Coronal axial image also.

Protocols for T-Spine of MRI
Routine
T2 Sag FSE
T1 Sag SE
T2 Sag STIR
T2 Axial FSE
T1 Axial SE

Special sequences
- T2 coronal FSE (Scoliosis)

Post contrast
- T1 COR
- T1 SAG
- T1 AXIAL

- Sagittal sections.
- Coronal images are used to plan for sagittal section. Then adjustments are done on the axial image also.
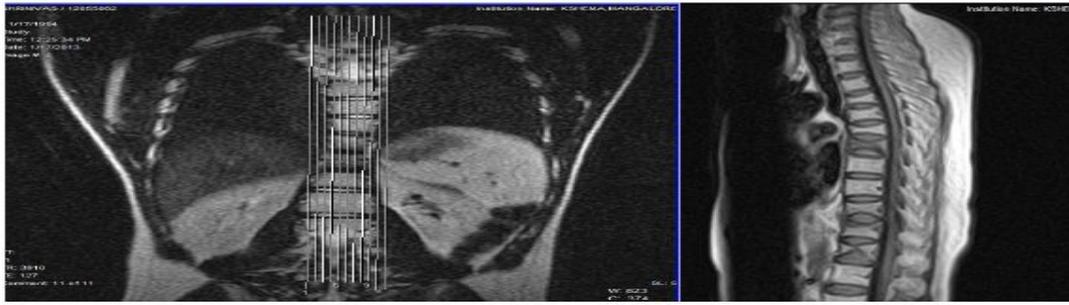
- Axial {TRUFI} section.

- Sagittal images are used to plan for axial section. Then adjustments are done on the coronal image also.
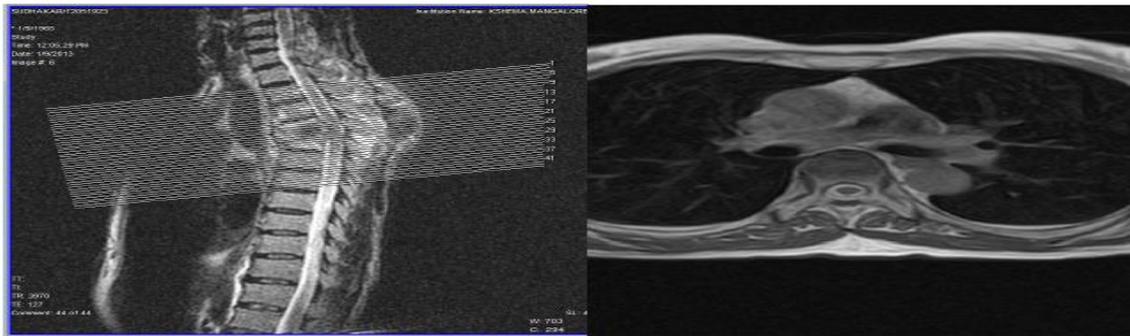
3.4 Lumbar sacral spine [L.S. SPINE]
Anatomy of L. S. spine
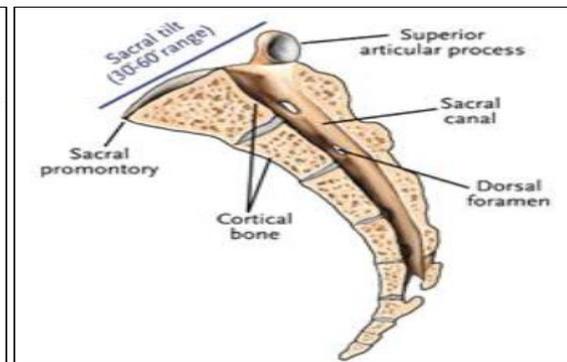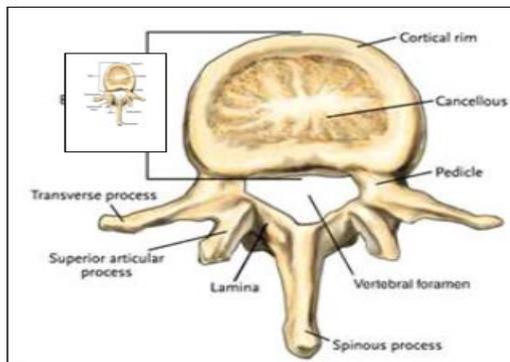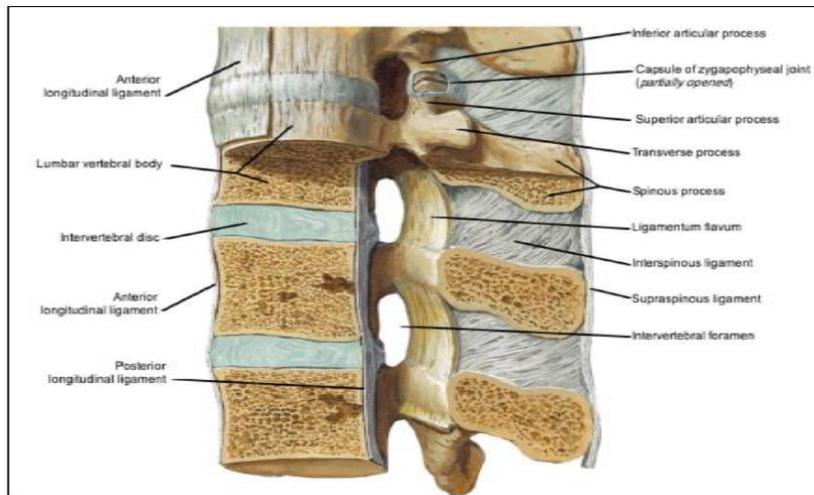
Indications
- Back pain
- Degenerative spine diseases
- Tumour (Benign and Malignant)
- Suspected spinal cord pathology
- Cauda equine compression
- Trauma.
- Spinal Stenosis

Contraindications
- All common contraindications

Patient preparation
- All common patient preparations

Position of Patient and Coil
- Supine and either head first or feat.

- Place the phase array coil on the table and plug the phase array coil port.
- Cushion the legs and secure them if needed
- Arms alongside the body (over the head for obese patients).
- Attach the p-gating device.
- Adjust the patient so that area of interest is center over the selected coil.
- Place the knee bolster, to flatten the lumbar curve and its make the patient as comfortable as possible.

Protocols of lumbar sacral spine
Coverage should be from T11down to S2 with sufficient to include left and right nerve root.
- Axial section.
- Sagittal images are used to plan for axial section. Then adjustments are done on the coronal image also.
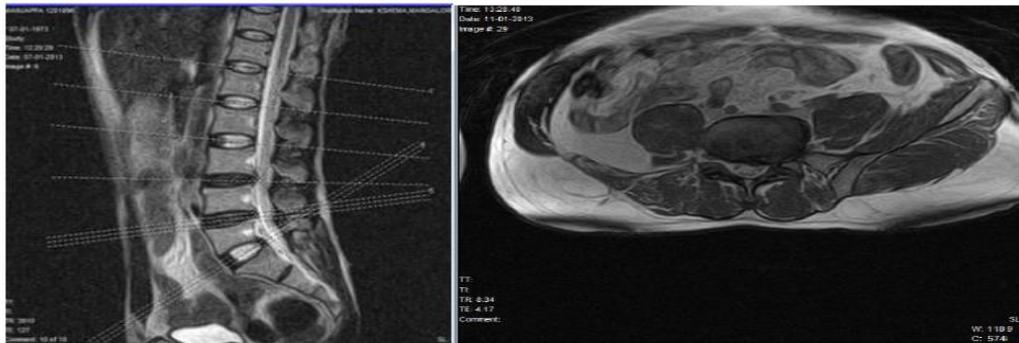
- Coronal section.

- Sagittal images are used to plan for coronal section. Then adjustments are done on the axial image also.
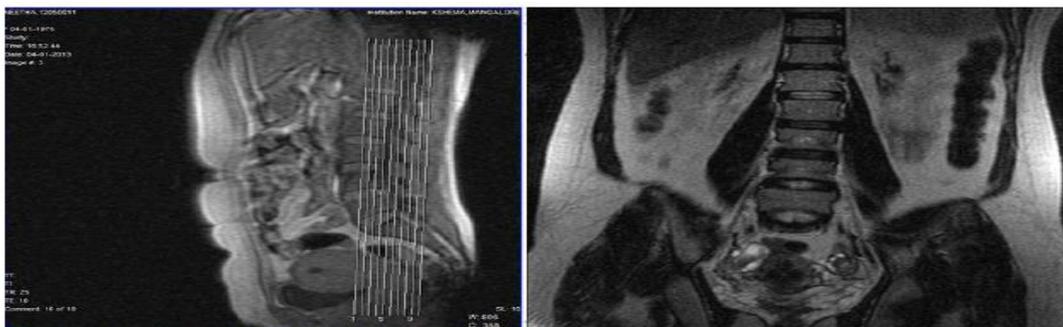
T1Recovery
- T1 recovery cause by the nuclei giving of their energy surrounding environment or lattice.
- As the T1 time of fat is shorter than the water, the fat vector realigns B0 faster than that of water.

T2 decay
- T2 decay is cause by nuclei exchanging energy with neighbouring nuclei.
- The energy exchange is cause by the magnetic fields of each nucleus results in decay is loss of transverse magnetization.

Routine protocols
T2 Sag
- Particularly useful for spaces, vertebral body heights and overall size of the lumbar spinal canal.
- Disc bulge or hernia ion like abnormalities, as well as heconus and filum terminal are also well visualized.

T1 sag. SE
- Bone marrow and neural foramina are best assessed this sequence.

T2 cor.SE
T2 axial SE
• Useful to assess the disk and determine if there is thecal sac and the nerve root compression.
• The facets are also best assessed using this sequence.

T1 axial SE
Useful to evaluate the bone marrow signal and neural foramen.

• Sagittal section.
• Sagittal images are used to plan for coronal section. Then adjustments are done on the axial image also.

Sag STIR SE
• Particularly useful to determine if there is oedema in the vertebral bodies and disc spaces.
• It is the great sequence to screen the spine for subtle abnormalities.

Post contrast
• FAT SAT SE T1 SAG
• FAT SAT SE T1 AXIAL
• FAT SAT SE T1 CORONAL.

Special protocols
• TRUFI; - If there is disc bulge or compression on spinal cords.

Myelogram
• FLAIR T1 axial TSE.

Whole spine
T2 SAG TSE
T1 SAG SE
T2 AXIAL TSE

3.5 MRI of pelvis
Anatomy of pelvis
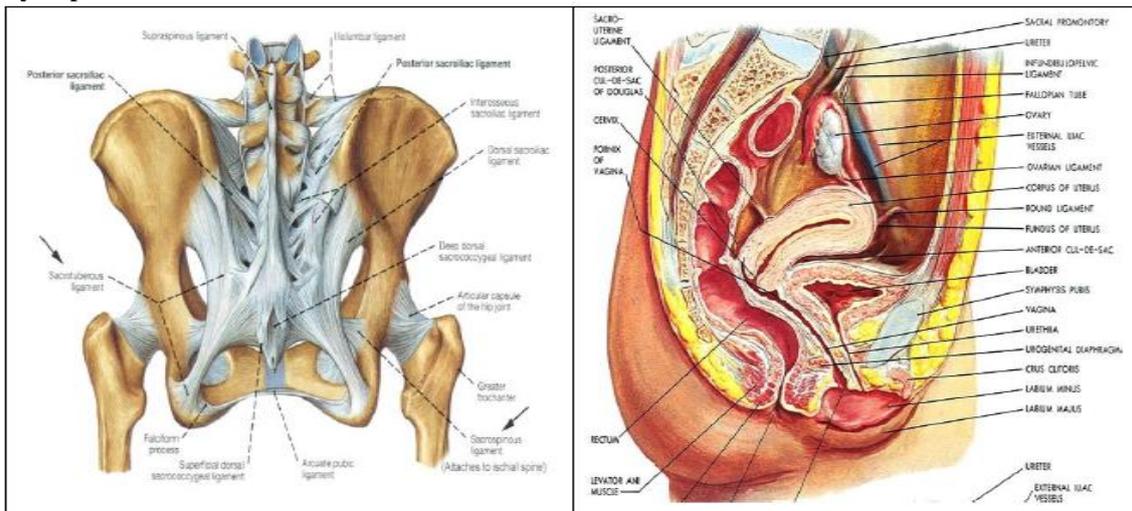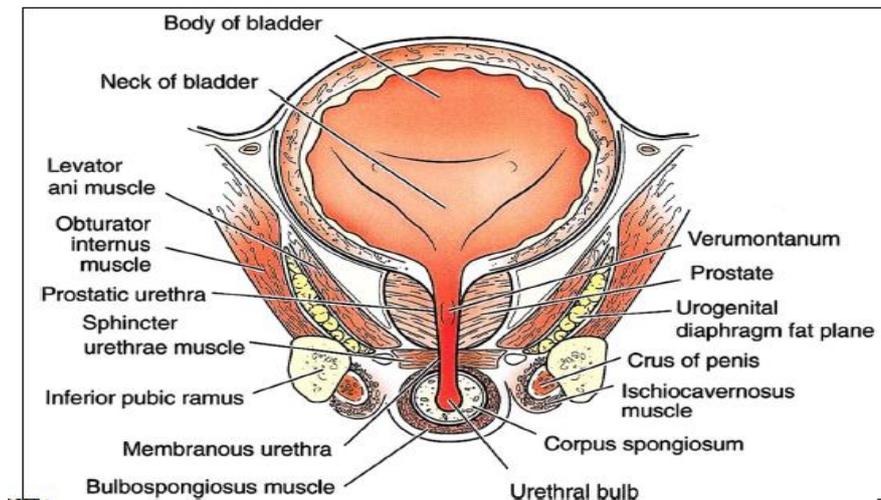
Indications
- Assessment congenital abnormalities of the urogenital tract.
- Diagnosis and staging of carcinoma of the cervix.
- Diagnosis of carcinoma of the uterus.
- Assessment of benign uterine tumors. (Leiomyoma and fibroids)
- Diagnosis of carcinoma of the bladder and rectum.
- Evaluation of rectal fistulae especially in patients with Crohn's disease.
- Evaluation of sacral lesions.

Contraindication
- All common contraindication.

Patient preparation
- An empty bladder can minimize motion artefacts from urine. However, a full bladder can aid visualization of bladder wall anatomy and pathology by improving definition between anatomies.

- Differentiating prostate from bladder wall.
- The empty bladder is required because it can reduce the artefacts, a signal from urine.
- Other common patient preparations.

Position of Patient and Coil
- Position the patient supine, feet first place an angle sponge under the knee for comfort.
- Place the pelvis array coil and plug it.
- Place the arms at the or overhead.
- Position comfort cushions an any pressure points. E.g. under elbow.

Planning: -Coverage should be from 4th lumbar vertebrae down to proximal part of femur with sufficient to include whole pelvis mussel an organ.
- Coronal section.
- Sagittal images are used to plan for coronal section. Then adjustments are done on the axial image also.
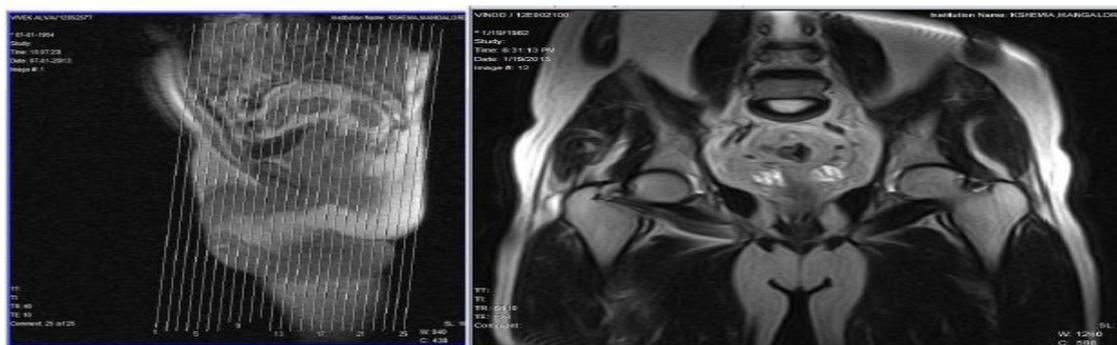
- Sagittal section.

- Coronal images are used to plan for sagittal section. Then adjustments are done on the axial image also.
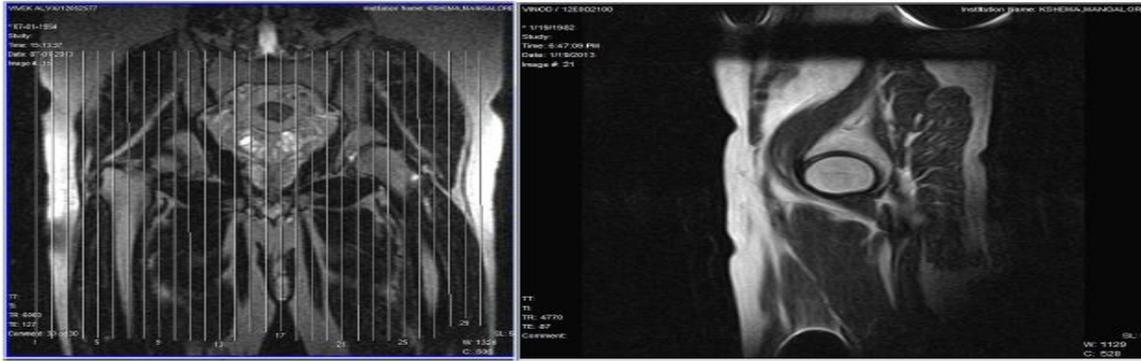
Protocols
Routine
- Localizer
- T2 sag, coronal and axial
- T1 axial
- T1 fat suppressed, axial, sag, coronal.

Post contrast
- T1 sag,
- T1 coronal,

- T1 axial

Special (If rectal cancer)
- T1 axial
- T2 sag, coronal, axial
- Axial T2 FST T1

4   Magnetic resonance angiography [MRA].
4.1 Brain
Normal anatomy of brain
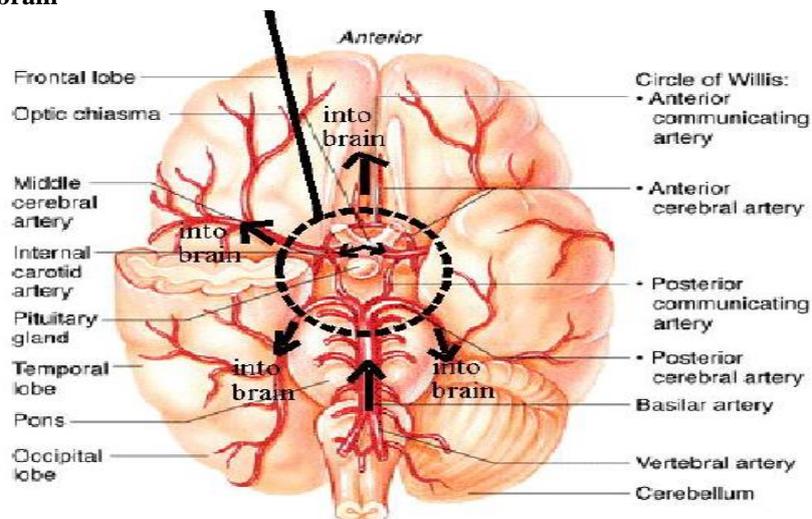
MRA of brain
- In MRA scan from base of skull to cortex of head.
- MRA provide images of blood vessels inside body.

Indications
- Circle of wills (stroke or TIA)
- Arterial ischemia
- Anterior venous malformations
- Stenosis

Contraindications
- All common contraindications.

Patient preparations
- All common patient preparations

Position of Patient and Coil
- Patient position head coil.
- Set of the head coil.
- Palace the patient in the head coil.
- Immobilize the patient using sponges and straps.

Planning of MRA of brain: -Coverage should be from cortex down to 4th ventrical with sufficient to include all the arteries
- 3D images
- Sagittal images are used to plan for 3D images. Then adjustments are done on the axial image also.
- MRA TOF 3D slab
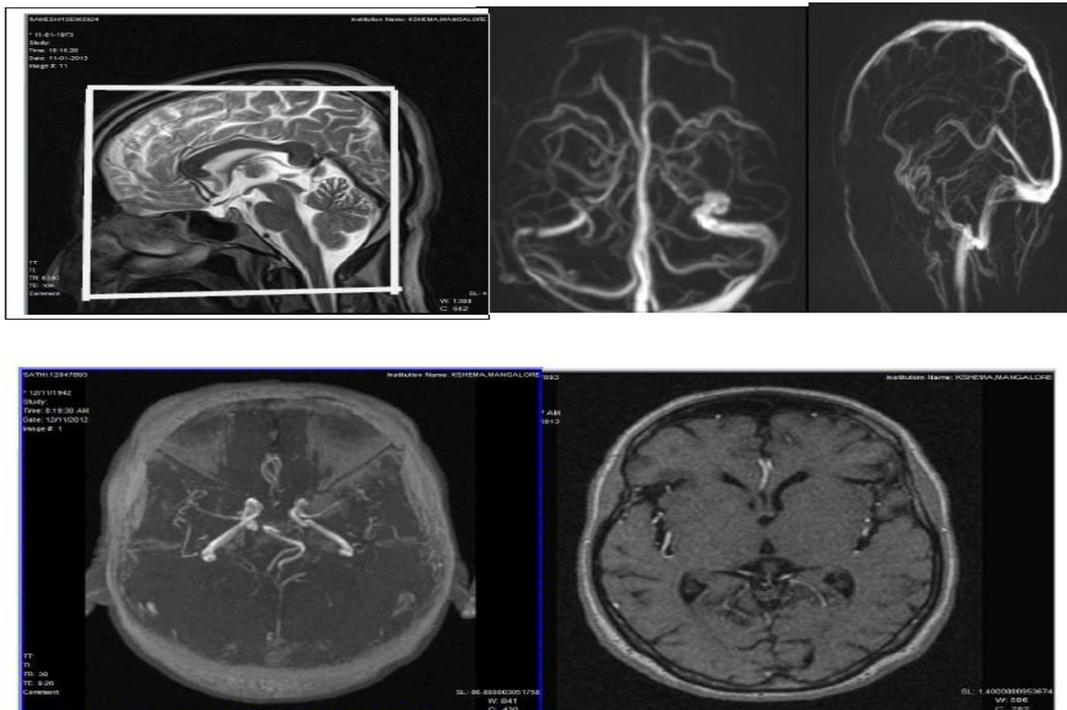
Protocol of MRA

MRA is the non-invasive method of study of blood vessels. Fast imaging technique like gradient echo one use for MRA. There are two methods of performing MRA, (1) TIME OF FLIGHT [TOF] (2) PHASE CONTRAST [PC].

- TOF: -
- In TOF angiography low flip angle is used and 180* phase is eliminated.
- Stationary tissue is exposed to multiple RF pulse and is fully saturated.
- Unsaturated blood entering this slice gives high signal. Obviously, maximum enhancement will be obtained when the imaging plane is at right angles to the direction of blood flow.

Phase contrast [PC]

- PC MRA is based on principle that flow of blood along a magnetic field gradient causes a phase shift in the MR signal.
- Images are obtained using different gradient polarities, [gradient of positive and negative polarity].
- These images are subtracted to delete stationary tissue so that only blood vessels are seen. Phase contrast sequences have to be encoded for specific peak velocities.
- Unlike multiple projection images are in TOF MRA, in PC MRA or signal collapsed image available from the subtracted phase, forma, the source image.

Routine protocols

- Axial 3D TOF, single slab.
- Axial 3D TOF-4 slab.

4.2 MRA NECK
Anatomy of neck
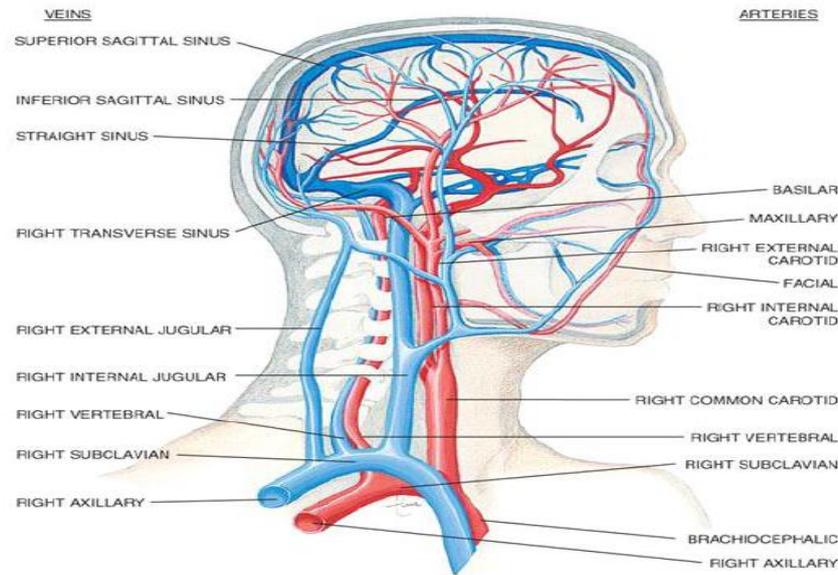
Indications
- Cervical carotid arteries strokes.
- Dissections of cervical carotid arteries.
- Occlusions of cervical arteries.
- Anterior venous malformations.
- Stenosis.
- Ischemia.
- Malformations.
- Any aneurysm.

Contraindications
- All common contraindications.

Patient preparation
- All common patient preparations.

Position of Patient and Coil
- Position the patient in supine, head first. Use the sponges or the head holder to sport the patient's head. Elevate the head slightly for the best coil fit.

- Place the coil the cover head and neck.
- Turn on the alignment lights and center the patient's midline [nose and sterna notch] to the sagittal lights.
- Move the coil as close to the patient's jaw as possible.
- Use the sponges or cushions as needed for patient comfort.
- Landmark at the center of the coil.
- Instruct the patient to breath evenly and minimize swallowing.

Planning of neck MRA: -Coverage should be from right transvers sinus down to arch of aorta
- Axial section.
- Coronal images are used to plane for 3D images. Then adjustments are done on the axial image also.

- 3D images.

- Coronal images are used to plane for 3D images. Then adjustments are done on the coronal image also.

Protocol
Sequences
- Localizer: Axial, Sagittal and Coronal.
- If a test bolus is being used then either use a coronal slice as the plane for the test bolus.
- Start sequence simultaneously with the injection of 2ml contrast, pre-injected into the line and followed by 20ml saline; e.g., Gd-BOPTA or gadobutrols.

Injection rate
- Bolus injection (approx. 2–3 ml/s). Determine the time required from the start of the injection until maximum signal (e.g., in carotid artery) is reached

[contrast circulation time] divide the total duration of the angiography sequence (sequence 2 below) by 2 and subtract the contrast circulation time from this result. This yields the time in seconds needed to start the contrast injection ahead of (for negative values) or after (for positive values) the start of the sequence.

Routine protocols
- Axial 2D TOF SPGR.
- Axial 3D TOF 6 slab.
- Coronal vasc. SPGR

5 Magnetic resonance venography [MRV]
5.1 MRV of brain
Anatomy of MRV of brain
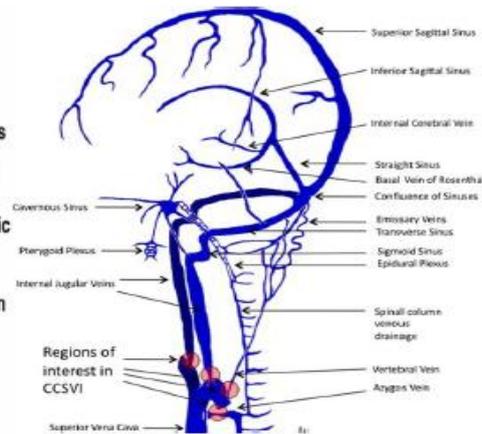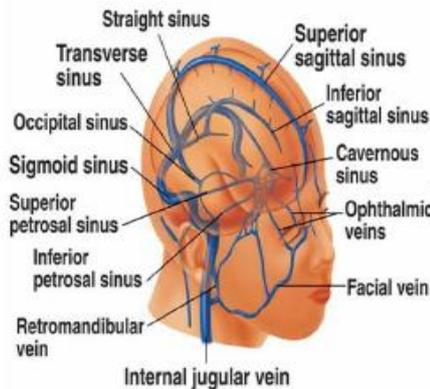
Planning
- 3D images

- 3D planning on coronal slice.
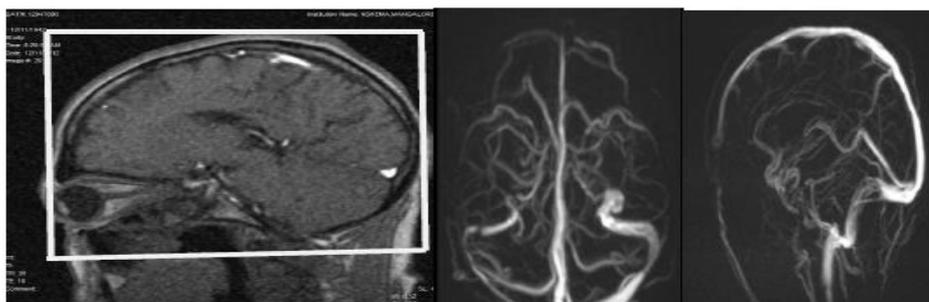
MRV of brain

MRI well suited to imaging the venous system, but because of high cost and limited availability used in selected cases of venous thrombosis in pregnant subjects and where fracture limbs and immobilized in casts.

Indications

- It is useful in evaluation of congenital abnormality.
- Venous malformations
- Stenosis.

Contraindications

- All common contraindications

Patient preparations

- All common patient preparations.

6. MRI of musculoskeletal joints
6.1 Temporal mandibular joints [TMJ]
Anatomy of TMJ
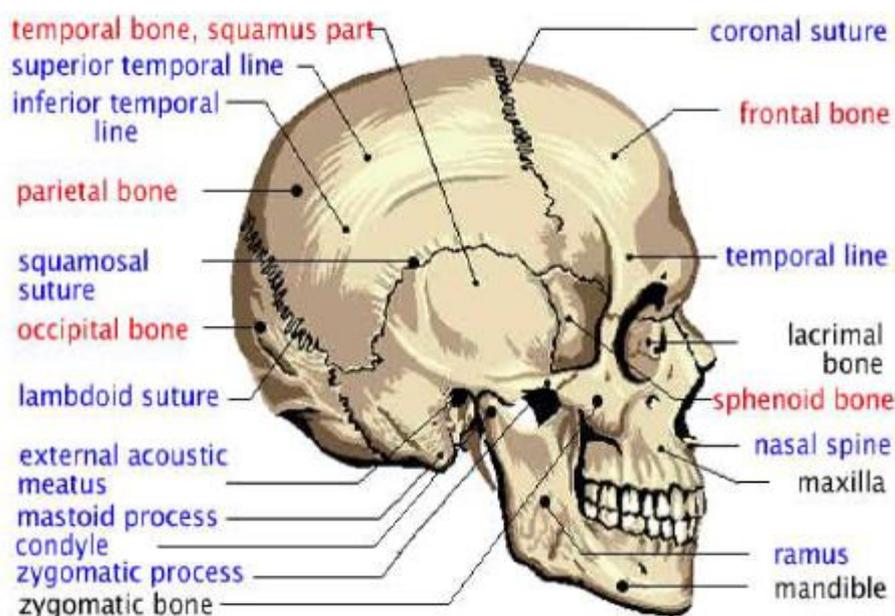
MRI OF TMJ

- **Both TMJ should include**

Indications

- Suspected internal maniacal derangements.
- Trauma
- Suspected fracture in TM joints
- Suspected pathology in TMJ

Contraindications

- All common contraindications

Patient preparations

- Thirty minutes before the study administer Gd - DTPA 0.2 m mol/kg body Weight (about 10−20 ml) intravenously (Indirect orthography).
- Explain the procedure to the patient and heck to see how far the patient can open his/her mouth, Fashion

Position of Patient and Coil

- Patient position is supine feet first.
- Set of the head coil.
- Palace the patient in the head coil.
- Immobilize the patient using sponges and straps.

Protocol for MRV of brain

- T1 SAG 2D PC
- T1 COR 2D PC
- T1 AXIAL 2D PC
- T1 COR 2D TOF

bite block (The mouth has to stay in maximum open position for several minutes), if not already done Practice fitting in the bite block with the patient.

- All common patient preparations

Position of Patient and Coil

- Supine
- Temporomandibular joint (TMJ) double coil (or head coil, or eye-ear coil or surface coil: e.g., flexible coil: position the head of the patient on the flexible coil, flip up the coil on the left and right side of the head and secure with straps).
- **Closed mouth:** Dual 3" inch coil.
- **Open mouth:** Dual 3" inch coil performs both closed and open mouth sagittal views.

Planning of TMJ MRI: - Coverage should be both TMJ
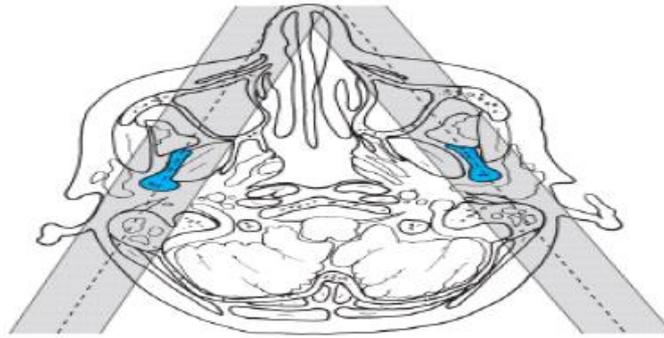
TMJ sagittal across each mandibular condyles

Protocol
Routine protocols
- T1 SAG FSE.
- T2 SAG FSE.
- SAG T2* GRE.
- COR T2* GRE.
- COR T1 SE.

- T1 SAG.
- T1 COR.
- T1 AXIAL.

Special protocols
- SAG 3D T2* GRE.

Post contrast
- Inject Gadolinium 10 ml, if pathological conditions seen acquire post contrast T1 weighted image in all 3 planes.

6.2 Knee joints
Anatomy of knee joints
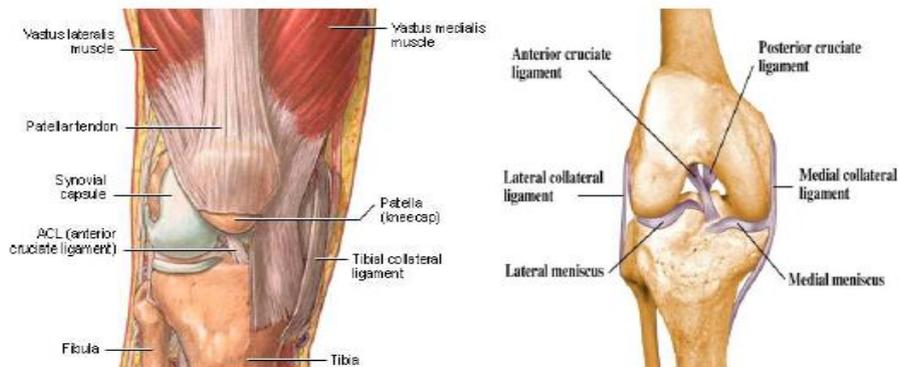
Indications
- Pain in knee joints.
- Trauma.
- Ligament tear.
- Post or pre- operative.
- Suspected pathology in knee joints

Contraindications
- All common contraindications.

Patient preparations
- All common patient preparations

Position the Patient and Coil
- Supine, feet first.
- Knee coil (Wraparound).
- Place knee into the coil (Check that it really is the one due for investigation)10–15° external rotation gives better imaging of the anterior cruciate ligament.
- Centre the joint in the coil and secure the knee in the coil cushion other leg.
- Sagittal section.
- Coronal images are used to plane for sagittal slice. Then adjustments are done on the axial image also.


- Axial section.

- Coronal images are used to plane for axial slice. Then adjustments are done on the sagittal image also.
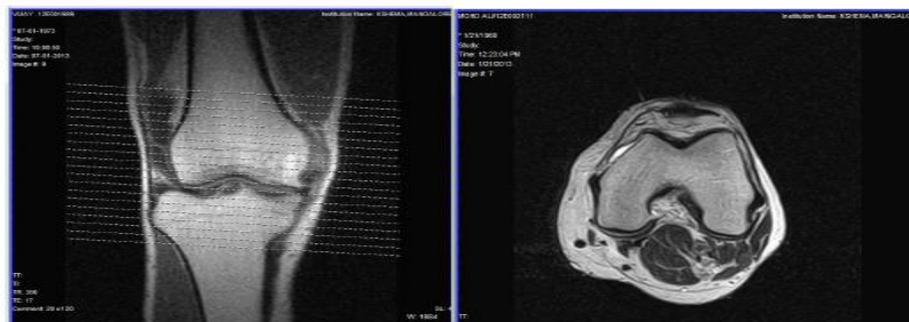
- Coronal section.

- Sagittal images are used to plane for coronal slice. Then adjustments are done on the axial image also.

Protocols
Routine protocols
• T1 SAG. SE.
• T2 SAG SE.
• T1 COR TSE.
• T2 COR TSE
• T2 COR FS TSE.
• T2 SAG FS TSE.
• T2 AXIAL TSE.

Special protocols
• 3D SAG DESS.

Post contrast
• T1 SAG
• T1 COR
• T1 AXIAL.

6.3 Ankle joints
Normal anatomy of ankle joints
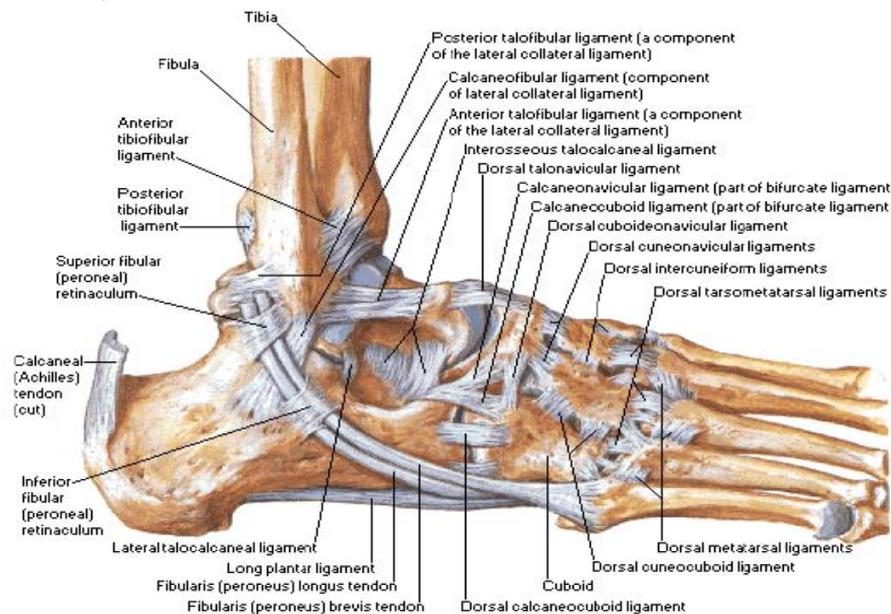
Indications
• Trauma.
• Vascular pathology.
• Ligament tear.
• Suspected pathology in ankle joint (Benign and Malignant)

Contraindications
• All common contraindications.

Patient preparations
• All common patient preparations.

Position of Patient and Coil
• Position of patient is supine.

• Knee coil (Head coil or wraparound coil for both ankles).
• Secure ankle in coil.
• Make sure that patient should comfortable.
• Cushion the other leg well.

Planning for ankle joints: -Coverage should be from distal tibia and fibula down to base of calcaneum with sufficient to include all related ligaments
• Axial section.
• Coronal images are used to plane for axial slice. Then adjustments are done on the sagittal image also.
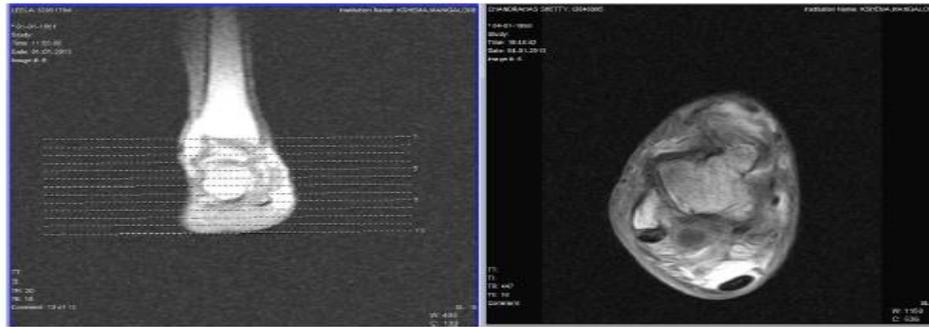
- Coronal section.

- Sagittal images are used to plane for coronal slice. Then adjustments are done on the axial image also.
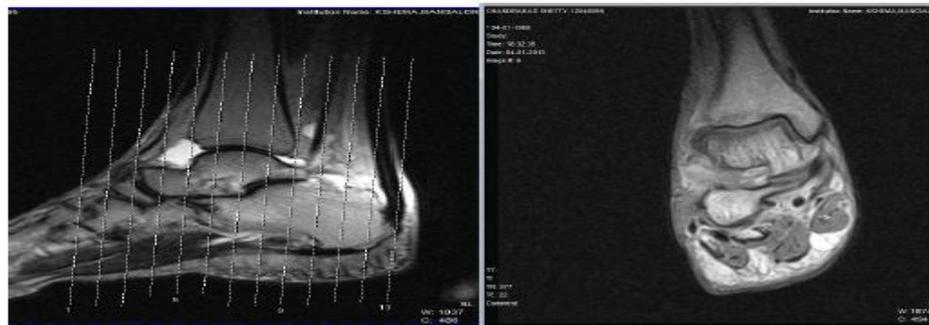
- Sagittal section.

- Coronal images are used to plane for coronal slice. Then adjustments are done on the axial image also.
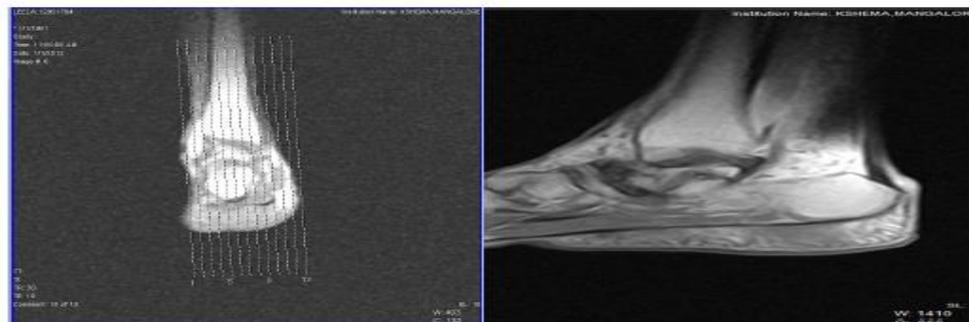
Protocol
Routine protocols
- T1 SAG
- T2 SAD
- T1 FSAG
- T2FSAG
- T1 AXIAL FSAG
- T2 AXIAL FSAG

Special protocols
- SAG 3D DESS.

Post contrast
- T1 SAG
- T1 COR
- T1 AXIAL.

6.4 Foots
Normal anatomy of foots
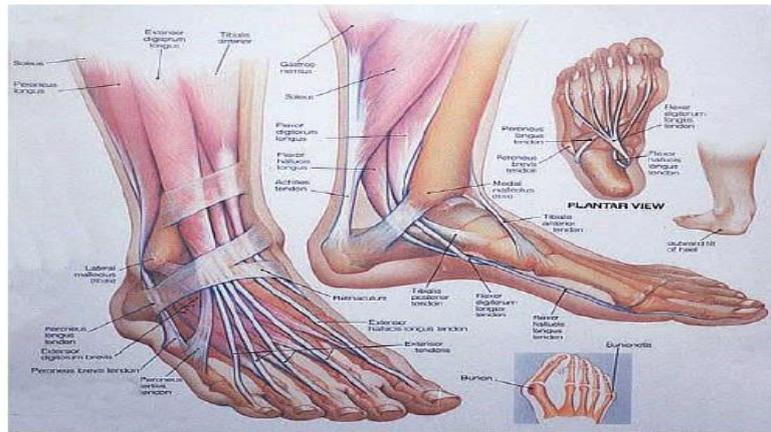
Indications
- Trauma.
- Vascular pathology
- Evaluation of ligament tear.
- Evaluation of benign and malignant pathology

Contraindications
- All common contraindications.

Patient preparation
- All common patient preparations.

Position of Patient and Coil
- Patient position is Supine: secure foot in coil (e.g., head coil, bring sole into the vertical and rest against some foam rubber or wraparound coil), cushion the other leg. Or prone: back of the foot flat against the table (e.g., in knee coil for improved signal-to-noise ratio.

**Planning for foot: - Coverage should be from 1 inch above the ankle down to whole foot**
- Axial section.
- Coronal images are used to plane for axial slice. Then adjustments are done on the sagittal image also.
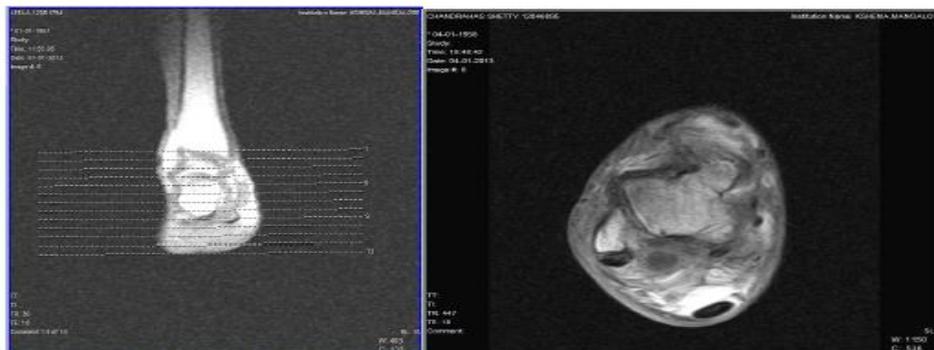
- Coronal section.

- Axial images are used to plane for coronal slice. Then adjustments are done on the sagittal image also.
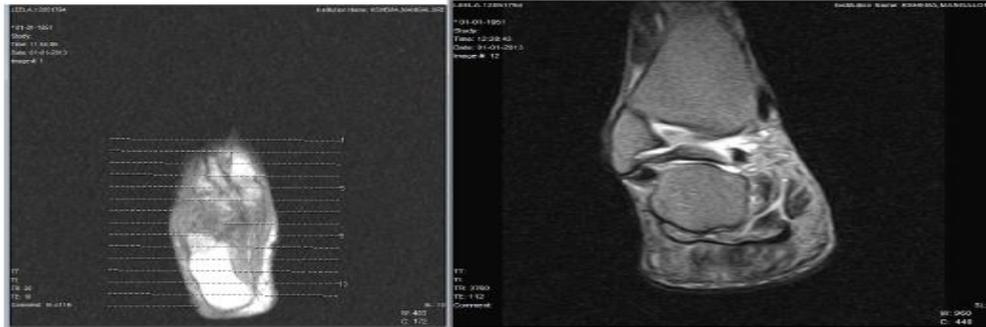
- Axial sections.

- Sagittal images are used to plane for axial slices. Then adjustments are done on the coronal image also.
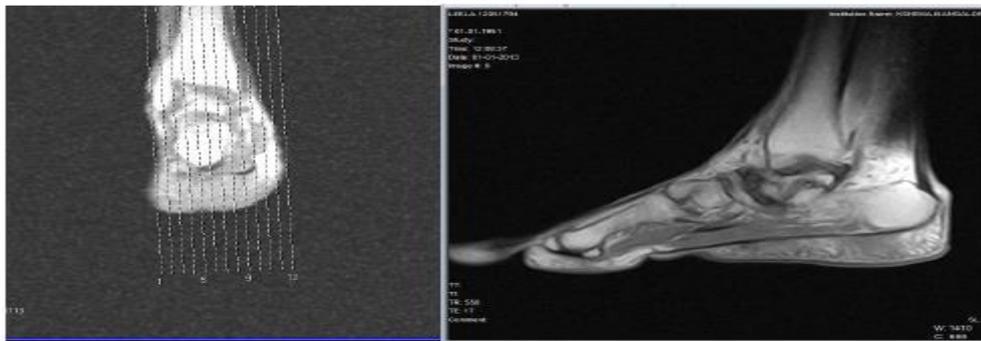
Protocols
Routine protocols
- T1 SAG SE
- T2 SAG SE
- T1 FSAG
- T1 FAT COR
- T1 AXIAL FSAG
- T2 AXIAL FSAG

Special protocols
- T2 Fl2d SAG

Post contrast
- T1 SAG
- T1 COR
- T1 AXIAL.

6.5 Shoulder joints
Anatomy of shoulder joints
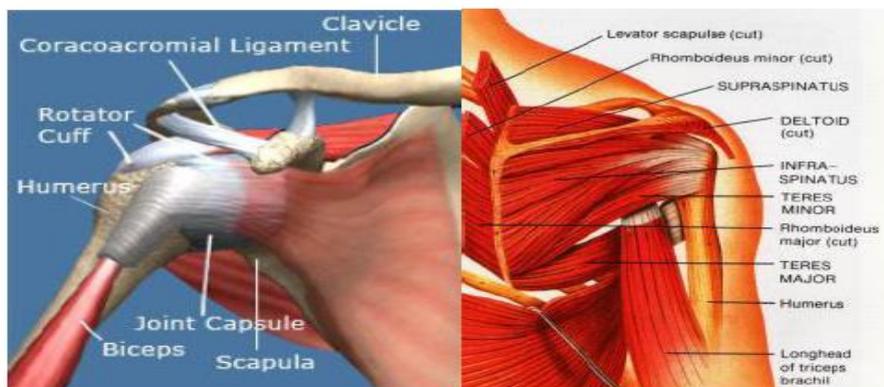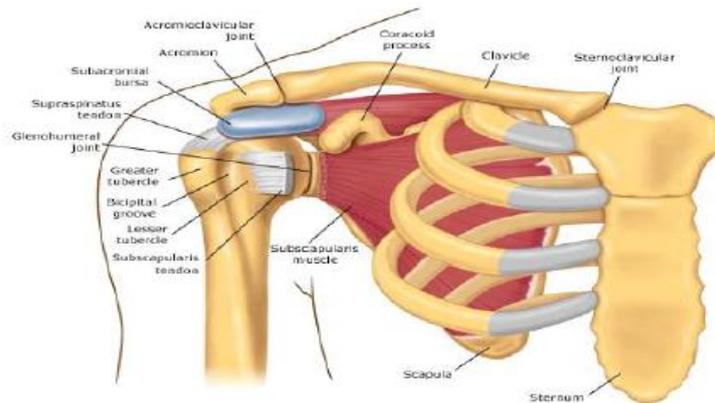
Indications
• Diagnosis and evaluation of impingement syndromes and stability.
• Rotator cuff disorders.
• To evaluate the any infections.
• It is also useful in evaluation of frozen shoulder syndromes.
• To evaluate the ligament tear & cartilage tears.
• Arthritis.
• To evaluate the cystic lesion.

Contraindications
• All common contraindications.

Patient preparations
• All common patient preparations.

Position of Patient and Coil
• Patient position is feet first supine.
• Shoulder coil (oval surface coil, flexible coil).
• Arm in neutral rotation or supination.
• Cushion the legs.
• Position the traps as far superior as possible to minimize the respiratory motions.

Planning: -Coverage should be supraspinatus muscle, Glenoid cavity with sufficient to include whole shoulder join
• Oblique sections.
• Sagittal images are used to plane for oblique slices. Then adjustments are done on the coronal image also.
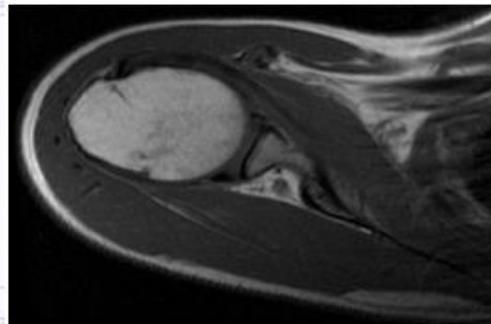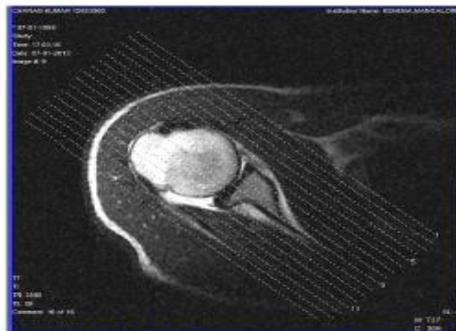

• Sagittal sections.

• Coronal images are used to plane for sagittal slices. Then adjustments are done on the axial image also.
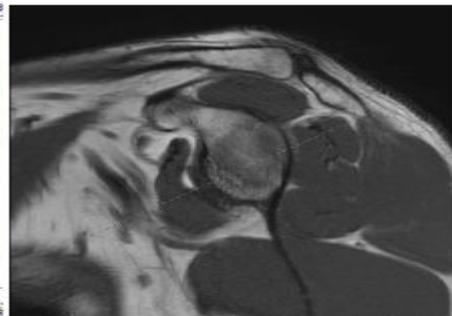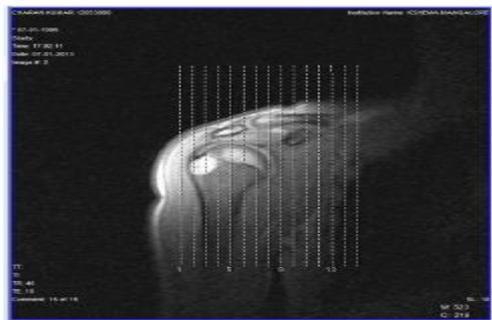
- Axial sections.

- Coronal images are used to plane for axial slices. Then adjustments are done on the sagittal image also.
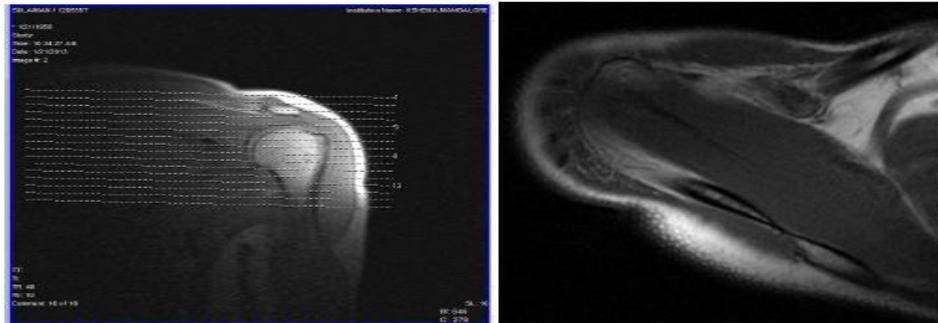
Protocols
Routine protocols
- T1 SAG SE FS.
- PD SAG TSE FS.
- T1 COR SE.
- T2 COR TSE.
- T2 AXIAL.

Special protocols
- T1 SAG SE FS ABER.

Post contrast
- T1 COR
- T1 SAG
- T1 AXIAL

6.6 Elbow joints
Anatomy of elbow joints
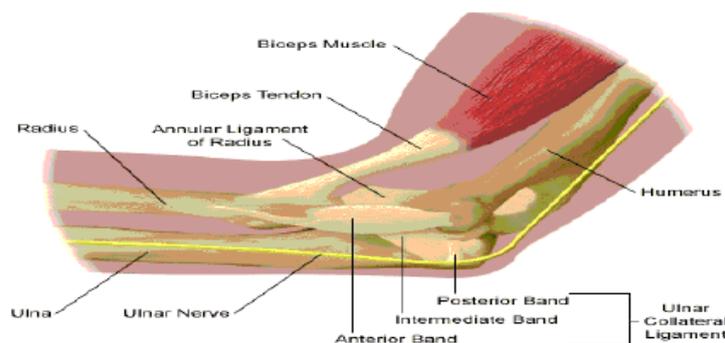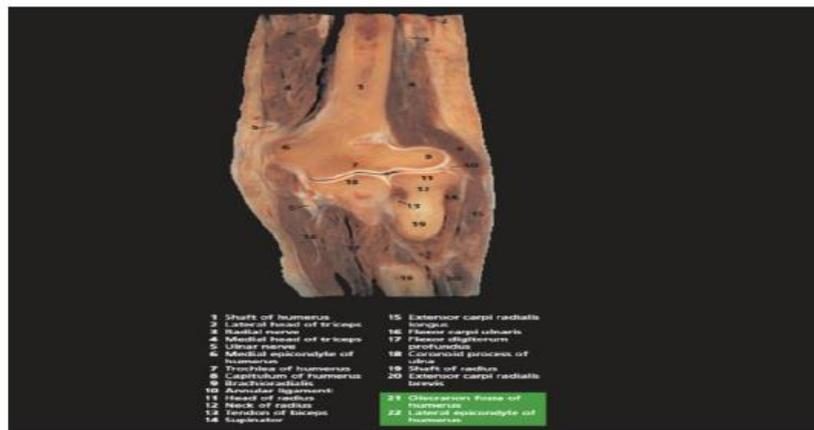
Indication
- Trauma
- Fracture
- Suspected benign and malignant pathology

Contraindication
- All common contraindications.

Patient preparations
- All common patient preparations.

Position of Patient and Coil
- Prone: arms straight above the head, palms against the table, secureor supine: arms straight alongside the body or slight lateral decubitus: arm immobilized by the body.
- Surface or wraparound coil.

Planning: -Coverage should be half of biceps tendon down to proximal part of radius and ulna with sufficient to include whole elbow join
- Sagittal sections.
- Coronal images are used to plane for axial slices. Then adjustments are done on the axial image also
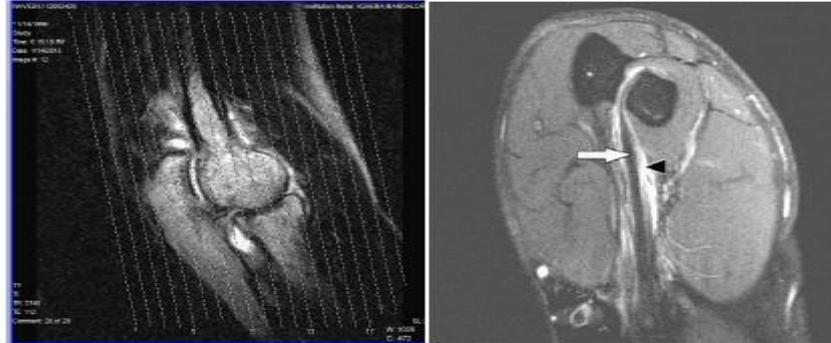
- Coronal sections.

- Axial images are used to plane for coronal slices. Then adjustments are done on the sagittal image also.
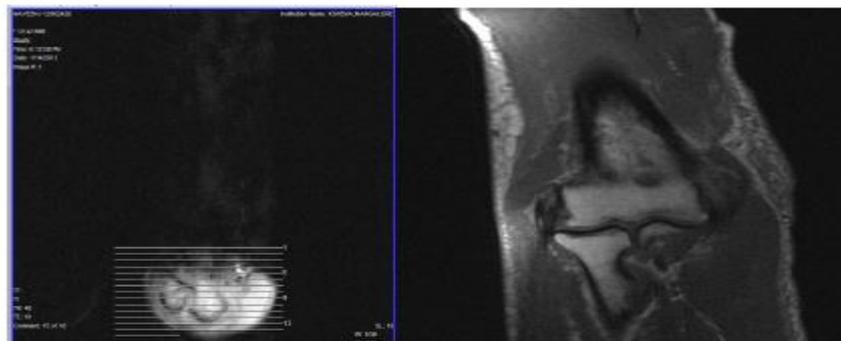
- Axial sections.

- Coronal images are used to plane for axial slices. Then adjustments are done on the sagittal image also.
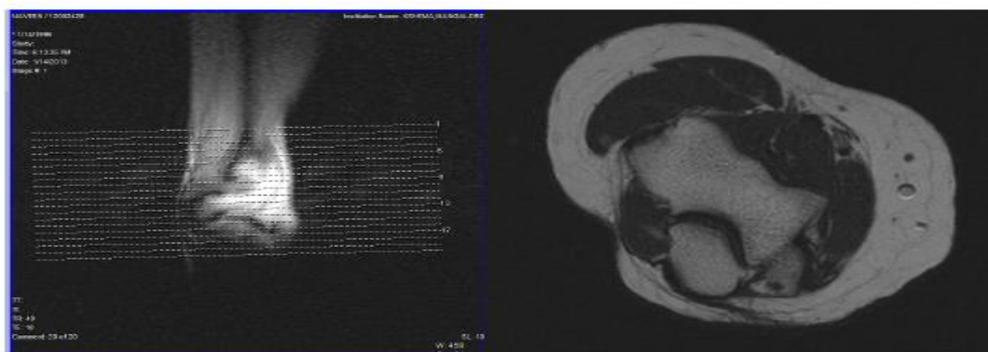
Protocols
Routine protocols
- T2 COR SE
- T1 COR SE
- T2 AXIAL
- T2 FAT SAT

Post contrast
- T1 COR
- T1 SAG
- T1 AXIAL

Special protocol
- T2 FAT SAG

6.7 Wrist joints
Anatomy of wrist joints
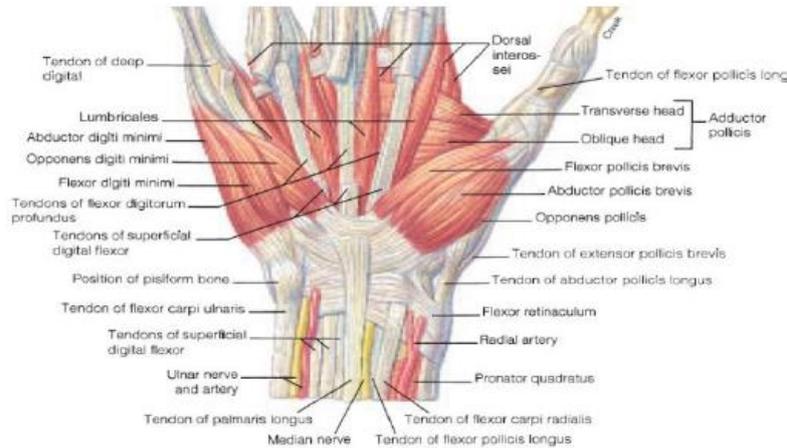
Indications
- Trauma
- Evaluation of benign and malignant pathological conditions.
- Evaluation of ligament tear.

Contraindications
- All common contraindications.

Patient preparations
- All common patient preparations

Position of Patient and Coil
- Prone: Arm extended above the head, palm flat on the table, secure, surface coil.
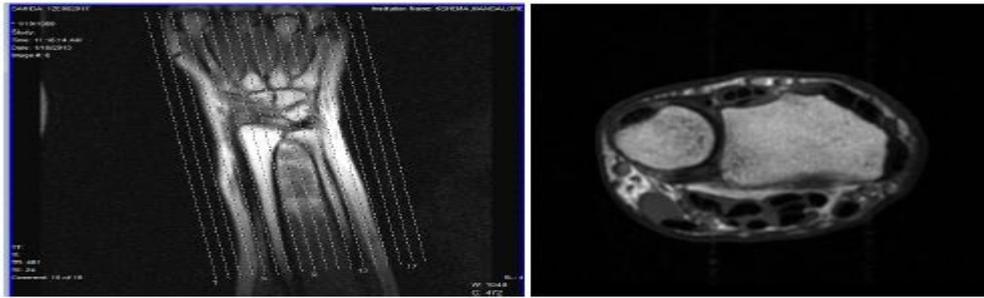- Supine: Arm extended alongside the body.

Planning: -Coverage should be whole wrist joint
- Coronal sections.
- Sagittal images are used to plane for coronal slices. Then adjustments are done on the axial image also.
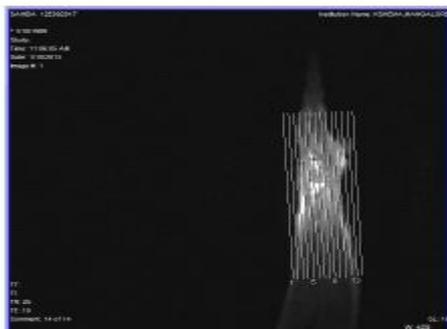
- Sagittal sections.

- Coronal images are used to plane for sagittal slices. Then adjustments are done on the axial image also

- Axial sections.

- Coronal images are used to plane for sagittal slices. Then adjustments are done on the axial image also.
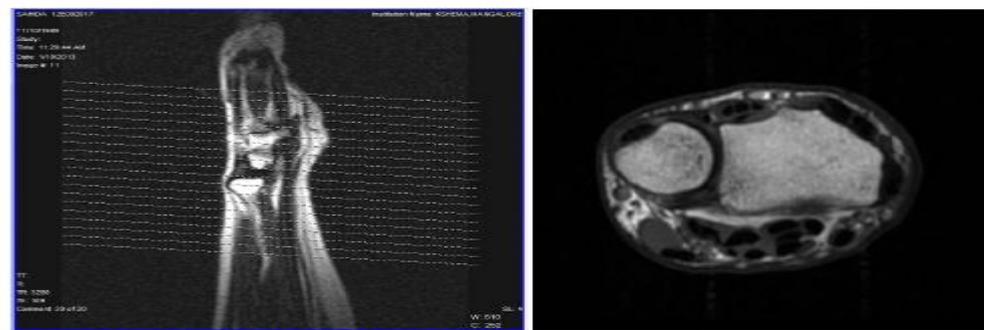
Protocols
Routine protocols
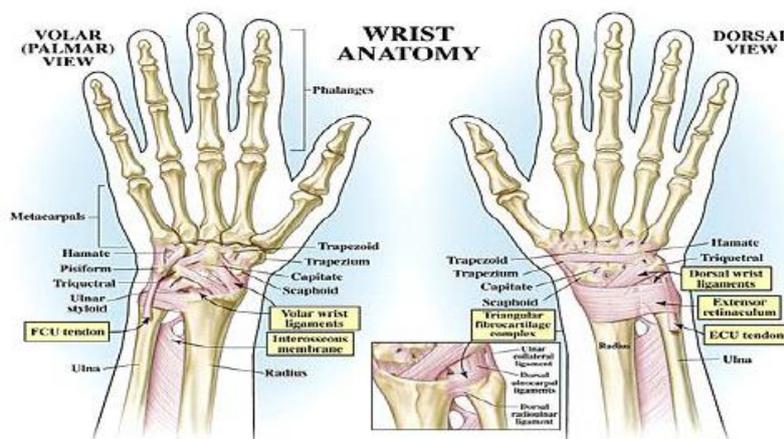- T1 COR SE
- COR STlR
- T1 AXIAL SE
- AXIAL PD TSE FS

6.8 Hands
Anatomy of hand

Special protocols
- SAG T2 FL

Post contrast
- T1 SAG
- T1 COR
- T1 AXIAL.

MRI of hand
Indications
- Trauma.
- Evaluation of benign and malignant pathology

Contraindications
- All common contraindications

Patient preparations
- All common patient preparations

Position of patient coil
- Prone: Arm straight above the head, palm against the table; secure;
- Surface Coil is used.
- Supine: Arm straight alongside the body.

Planning: -Coverage should be including wrist join down to phalanx with sufficient to include hand muscle and ligaments
- Axial sections.
- Sagittal images are used to plane for axial slices. Then adjustments are done on the coronal image also.
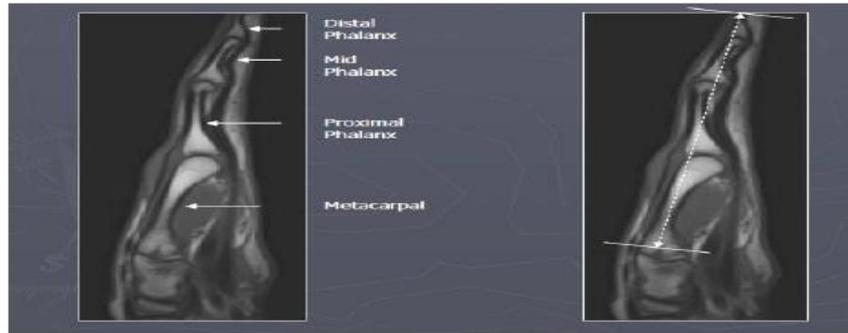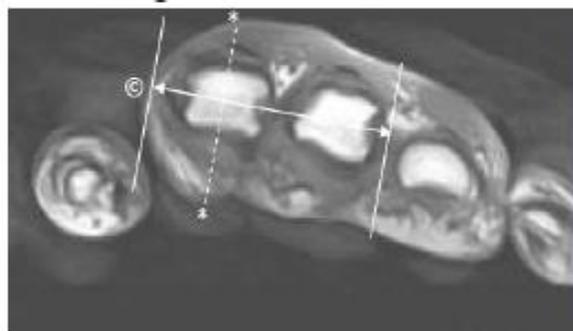

- Coronal sections.

- Axial images are used to plane for coronal slices. Then adjustments are done on the sagittal image also.
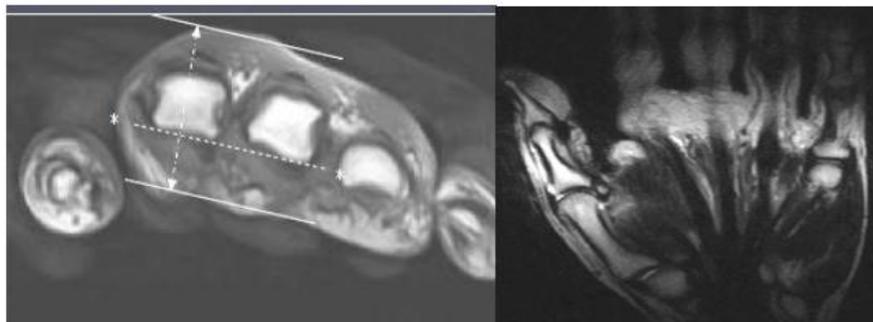
- Sagittal sections.

- Axial images are used to plane for sagittal slices. Then adjustments are done on the coronal image also.

Protocols
Routine protocols
- T1 SAG SE
- T2 SAG SE
- T1 COR TSE
- T2 FSAG
- T2 AXIAL

Post contrast
- T1 SAG
- T1 COR
- T1 AXIAL.

7. RESULTS, CONCLUTIONS, REFERENCES, INFORMED CONSENT

7.1 RESULTS

This study has several important strengths. To standardize the MRI protocols. These protocols may be used for all the centers in the absence of radiologist, Technologist will be able to perform the study according to the clinical history of the patients and diagnostic accuracy can be made consistent. our result can be used to optimize MRI protocol for quality of patient care and for throughput in MRI. In research hospitals, various sequences could be inserted between contrast agent injection and the contrast-enhanced image acquisition 5 min later. These could include dynamic susceptibility contrast (DSC), DCE, contrast-enhanced FLAIR, and more. In more rural settings, a standard enhanced FLAIR for leptomeningeal pathology could be inserted during the 5 min waiting time. Above all, accurate knowledge of the optimal waiting time could help to improve the patient's comfort level by reducing the MRI examination time.

7.2 CONCLUTIONS

This study show that applied moshed of advanced protocols of magnetic resonance imaging can save the time and as well as improved the quality of magnetic resonance imaging images, it also helps the Radiologist for reporting because there will be some less images and save their time, this saves time can used for another ill patients those who need it. Protocol optimization would have to be performed on a per scanner and per protocol basis. Proper optimization might make accurate aortic flow quantification possible for most scanners.

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