Philips 3T Achieva

3T Knee Invivo 8CH Knee Coil

Sequence	SagT1	SagPDFS	CorT1	CorPDFS	AxPDFS	SagPD
Resolution (mm)	0.42x0.52x2.80	0.55x0.71x3.00	0.40x0.78x3.00	0.40x0.50x3.00	0.38x0.59x3.00	0.52x1.03x3.00
FOV (mm)	160x160	140x140	140x129	140x126	130x118	120x120
Matrix	384x307	256x196	348x164	348x250	344x200	232x116
Phase Direction	AP	FH	RL	RL	RL	AP
# of Slices	24	28	35	35	30	22
TR/TE (msec)	581/20	3368/30	1042/6.8	4768/20	4060/20	2480/30
Echo Train (ETL/TF)	6	14	7	17	17	15
WFS (BW)	1.487/292.1	1.764/246.3	1.581/274.8	1.361/319.3	1.512/287.4	1.383/314.3
Parallel Imaging	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx2	Yes-SENSEx1.5	Yes-SENSEx2	Yes-SENSEx2
Foldover Supp (NPW)	No	Yes	No	No	No	No
DRIVE (FRFSE)	No	No	No	No	No	Yes-SENSEx2
Fat Sat	No	Yes-SPAIR	No	Yes-SPAIR	Yes-SPAIR	No
NSA (NEX)	2	2	2	1	2	4
Scan Time	1:35	1:41	1:48	1:44	1:45	1:24

Abbreviations

Asym.: Asymmetric k-space profile order (see over)

ETL/TF: Echo Train Length or Turbo Factor, the number of k-space lines after an excitation pulse

FOV: Field of View

FFE: Fast Field Echo, also GRE

DRIVE (FRFSE): Driven Equilibrium mode, also called Fast Recovery Fast Spin Echo

IP: In-Phase, gradient echo TE to keep fat and water in resonance

NSA (NEX): Number of Signal Averages or Number of Excitations

FOS / NPW: Foldover Suppression / No Phase Wrap, conventional oversampling method to prevent image fold-over

PD: Proton Density, weighting for short TE, long TR spin-echo scans

POS: Phase OverSampling (see over)

SAR: Specific Absorption Rate; tissue heating measure limited by the FDA

SENSE: SENSitivity Encoding, Philips parallel imaging method (c.f. ASSET; iPAT) which uses the coil sensitivity profiles to speed up imaging or suppress wrap. All parallel imaging methods depend upon multiple-element coils

SNR: Signal to Noise Ratio, measure of image quality

SPAIR: Fat suppression technique using adiabatic pulses (more details overleaf)

WFS: Water-Fat Shift (see over), a measure of receiver bandwidth (BW)

SAG T1


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 7 - Slice 19/24
TSE
North Memorial Medical Center
Slice Thk 2.8 / 0.8
FOV 160mm
H
A
P
F
L 1477
W 2705
9:41 AM
7/31/2008

SAG PD FS


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 9 - Slice 22/28
TSE
North Memorial Medical Center
Slice Thk 3.0 / 0.3
FOV 140mm
H
A
P
F
L
L 1066
W 1772
9:41 AM
7/31/2008

COR T1


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 4 - Slice 18/35
TSE
North Memorial Medical Center
Slice Thk 3.0 / 1.0
FOV 140mm
H
R
A
L
F
L 26387
W 40079
9:41 AM
7/31/2008

COR PD FS


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 5 - Slice 19/35
TSE
North Memorial Medical Center
Slice Thk 3.0 / 1.0
FOV 140mm
H
R
A
L
F
L 3427
W 6063
9:41 AM
7/31/2008

AX PD FS


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 3 - Slice 21/30
TSE
North Memorial Medical Center
Slice Thk 3.0 / 0.8
FOV 130mm
A
R
L
P
L 1065
W 1879
9:40 AM
7/31/2008

SAG PD


PMS 3T KNEE, 1234, 7/6/1976, M
Scan 6 - Slice 17/22
TSE
North Memorial Medical Center
Slice Thk 3.0 / 1.0
FOV 120mm
H
A
P
F
L 1379
W 2292
9:41 AM
7/31/2008

Philips Achieva Tips

Protocol Optimization

3T SNR can be traded like currency for imaging speed or resolution

- When emphasizing resolution, high SENSE factors are not used for speedup. However, using SENSE with factor 1 futher improves SNR over no-SENSE because coil sensitivity profiles are used for more optimized array reconstruction

- The high in-plane resolution in these 2-D scans could be traded for thinner slices. Inter-slice gaps are10% of slice thickness

- Signal averages can be used to further improve SNR, but longer scans risk movement blurring

- Reducing SNA or increasing SENSE factors can achieve faster scanning. It may be necessary to use slightly larger coxels to maintain SNR.

- Dedicated multi-element receiver coils are recommended for the best signal.

Bandwidth & Water-Fat Shift (WFS)

Direct specification of Water-Fat Shift in pixels is used as an alternative to bandwidth in kHz

- WFS is field strength, pixel size and FOV independent measure of potential artifact and impact on SNR.

- For MSK imaging, keep WFS between 1-2.5 pixels to avoid obscuring pathology (0.5-1.5mm shift).

- Reducing WFS, (increasing BW), reduces echo spacing, which reduces TSE shot lenth and reduces blurring.

- Reducing WFS (increasing BW) reduces SNR.

Conversion Factors:
3T: BW kHz = (0.22kHz) (freg matrix)/(WFS pixels)
1.5T: BW kHz = (0.11kHz)(freq matrix)/(WFS pixels)
Example: WFS = 1.76 pixels with a 512 matrix on 3T
BW (kHz) = (0.22kHz)(512)/(1.76) = +/-64kHz

Turbo or Fast Spin Echo

Asymmetric k-space profile ordering is used to reduce scan time by 30% in PD and T1w exams while minimizing

- Asymmetric Turbo Spin Echo scans permit independent specification of TE, Echo Spacing and Echo Train Length.

- Shot lenth (ETL x Echo Spacing) should not exceed 4 x TE.

- If a different profile order is used (such as linear or centric), reduce the ETL on these protocols by about 30%. Scan times will increase proportionately.

- DRIVE (Driven Equilibrium) or Fast Recovery FSE (FRFSE)
  -Consider use to brighten fluid when TR < 3000ms
  -Can be applied to adjust contrast for longer TRs

- Alternative approach: 3D gradient echo scans can supply high resolution and SNR with T1 or T2 weighting, and permit reformatting. Apply SENSE to lower scan times

Image Resolution

Voxel size is specified explicitly. This provides a direct measure of lesion size conspicuity.

- Resolution remains fixed independent of FOV changes, and precludes the need for other adjustments, such as rectangular FOV or scan percentage, that could inadvertently change voxel dimensions.

- The in-plan voxel size is related to the FOV/Matrix; voxel dimensions presented correspond to the frequency x phase x slice thickness.

- Reconstruction resolution can be independently specified. Display resolution should not be confused with the acquired voxel size.

- Interpolation (ZIP) is used to reduct the reconstructed voxel size, which can improve the visualization of thin curved structures like cartilage.

- higher field strength, new coils, hardware and pulse sequences have allowed us to reduce voxel sizes at 3T by a factor of 2-3 versus 1.5T for comparable protocols.

- For example: Sagittal TSE PD Knee at a 12cm FOV;
  1.5T MRI: 384x256 matrix, 4mm slick thk = 0.58mm3
  3.0T MRI: 600x424 matrix, 2.5mm slick thk = 0.14mm3

Fat Suppression Techniques	**Uniform fat suppression improves CNR for better specificity** • SPAIR (Spectral Attenuated Inversion Recovery) -Fat saturation very robust against RF inhomogeneity -Adjustable degree of fat suppression: Increase SPAIR inversion time (T1) for softer fat sat -Preferred at 3T for PD, gadolinium enchanced T1 scans (T1 range: 70-200ms based on degree of fat suppression desired). • SPIR (Spectral Presaturation Inversion Recovery) -Uses smaller flip angle inversion pulse than SPAIR -More vulnerable to RF inhomogeneity at 3T, but shorter prepulse may be helpful in some applications and scan times • ProSet (Water selective excitation) -Best for 3D gradient echoes • STIR (Short Tau Inversion Recovery) -Robust against Bo and RF inhomogeneity -Helpful with metal artifact imaging -Do not use with contrast enhancement • Higher-order Shimming (PB-Volume) -For off-center imaging such as shoulder and wrist imaging -Better fat suppression by improving field homogeneity	**Turbo or Fast Spin Echo**	**Phase wrap control varies with the acquisition technique (multiple choices)** • Define a large enough FOV to completely cover the anatomy. This will prevent aliasing, but may require zooming during image review to focus on the anatomy of interest. • Use foldover suppression: -If NSA = 1, Aliasing is avoided by use of saturation bands. -If NSA is 2 or 3, the acquired FOV is doubled or tripled respectively "behind the scenes", the # of averages actually obtained is 1. • For SENSE imaging, use SENSE Phase OverSamping (POS) by a suggicient factor to account for anatomy outside the FOV. -SNR, scan time and resolution are not affected. -POS is independent of NSA. -POS requires SENSE capability in the given direction. • Use saturation bands to eliminate signal from adjacent anatomy that is vulnerable to motion (e.g. lungs in shoulder imaging).
Metal Implants or Prior Surgery	**Implanted metal may produce artifacts, but that doesn't preclude diagnostic-quality images.** • Consider scanning at a lower field strength (1.0, 1.5T) • Use Spin echo and Turbo Spin Echo methods. • Use 7-8ms echo spacing, for a TSE, select echo spacing • Shortest€. Use WFS <1.5 pixels, on 3T, <0.7 pixels, on 1.5T or select minimum. This typically corresponds to a BW over 50 kHz. • Consider swapping phase and frequency directions and using thinner slices (<4mm) to reduce through-plane dephasing. • If fat suppression doesn't work, use STIR. A T2-weighted gradeitn echo (FFE) scan can be used to identify prior surgical procedure sites.	**Contrast Options**	• TSE PD FS provides excellent contrast between fluid, cartilage, and bone. • FFE Variations (set contrast method to): -No enhancement (GRASS) for high fluid signal using steady state imaging and 20•-90• flip angles/ -T1 enhancement (SPGR) for high cartilage signal using low flip angles. -Balanced FFE (TrueFISP, FIESTA). For best 3T results, use in-phase TR/TE, e.g. 9.2/4.6msec and careful shim. • Quantified values: T1 and T2-maps • For gradient echo scans at 3T, a colume shim is often applied to improve a joings Blhomogeneity.
MR Angiography	**MR Arthrography is commonly based on T1-weighted fast suppressed imaging.** • T1-weighted scans are split into multiple "packages" to keep TR short but not restrict the number of slices. -Selecting a "TR range" between 450-700 sets this up. • SPIR or SPAIR may be used (do not use STIR) • Isotropic 3D gradient echo scans using water excitation such as ProSet can supply high SNR with T1-weighting, permitting arbitrary slice plane refomatting. Apply SENSE to lower scan times.	**RF Management**	**3T Turbo Spin Echo scans don't have to be slow because of SAR limitations.** • Refocusing control -Consider lowering the refocusing angle to 100-120 degrees -Flip angle sweep allows a smooth transition to the steady state for scans using refocusing control. • B1 mode -Consider reducing the B1 amplitude to 12 mT for multi-package scans. • Knee/Ankle/Foot imaging -The system uses anatomy specific, more permitting SAR calculations with SENSE knee and SENSE foot/ankle coils.