MRI Quality Assurance Phantom JMR II

Instruction Manual

Contents

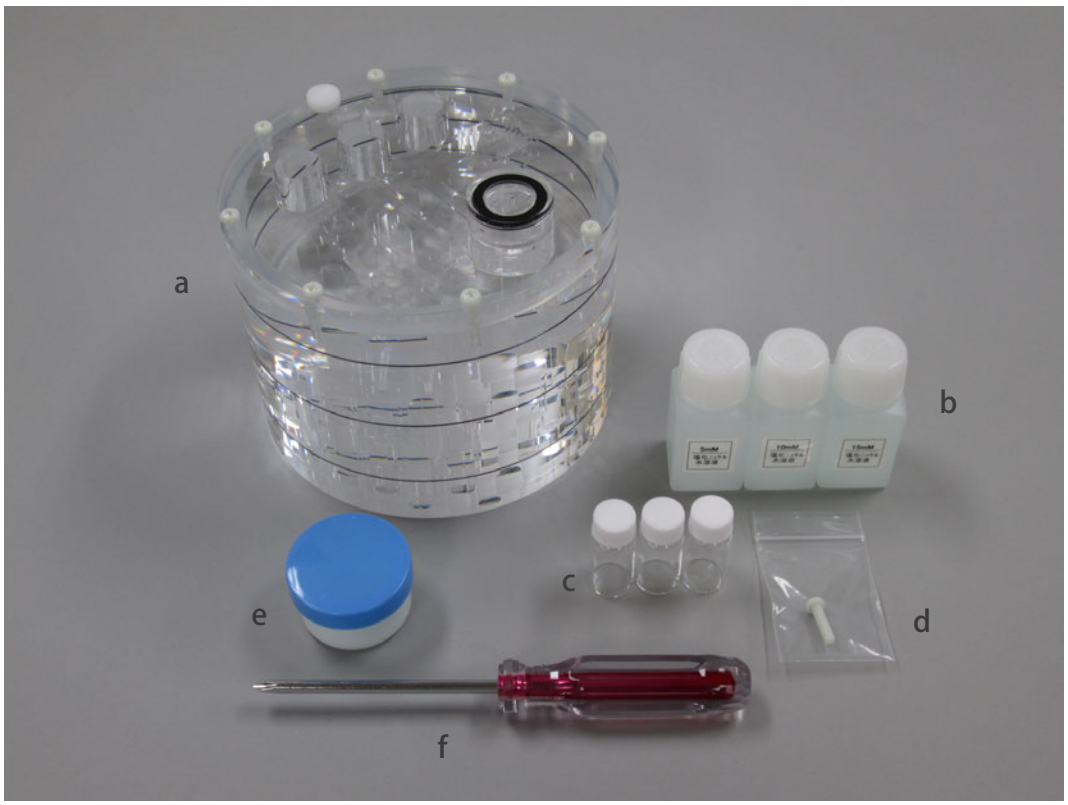
KYOTO KAGAKU

Before you start

DOs and DONT's

Set includes

Before use, please ensure that you have all components as listed below.



a	phantom unit	1 x	e	petroleum jelly	1 x
b	NiCl 50ml（5, 10, 15mmol）	3 x	f	phillips head screwdriver	1 x
c	sample bottle (9ml)	3 x		manual	1 x
d	extra screw	1 x			

⚠ caution

- **Handle the manikin and the components with care.**
  As the material is from hard resin, please refrain from dropping it or to hit it with a hard object.
- **Only use water or neutral detergent to wipe the phantom.**
  Never use organic solvents such as paint thinner to clean the phantom.
- **Please keep away from high temperature and humidity.**
  After use please store it in a cold and dry space away from the sun, to prevent deformation or the malfunction of the phantom.
- **Don't use felt pen or marker on this phantom.**
  · In this case the ink could leave stains on the phantom.

Specification of the phantom

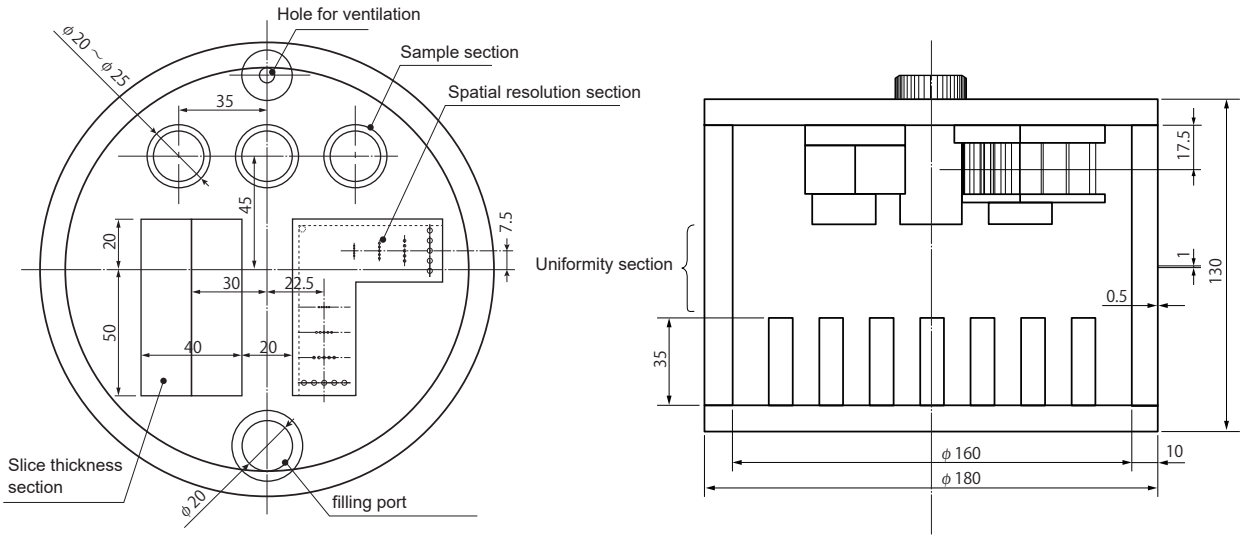
phantom unit — acrylic container outer diameter 180 ㎜

Cylindrical vessel includes parts for

- Signal-to-noise-ratio (SNR)
- Image uniformity
- Slice thickness
- Spatial resolution
- Geometric distortion
- Ghost imaging
- Image contrast evaluation

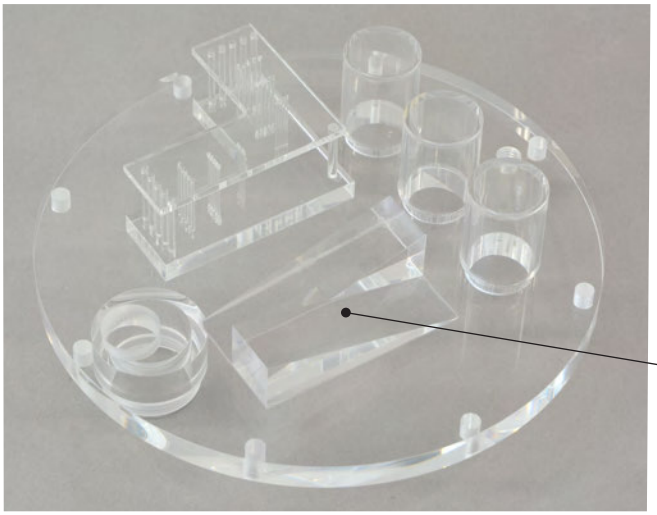
Structural design

unit mm



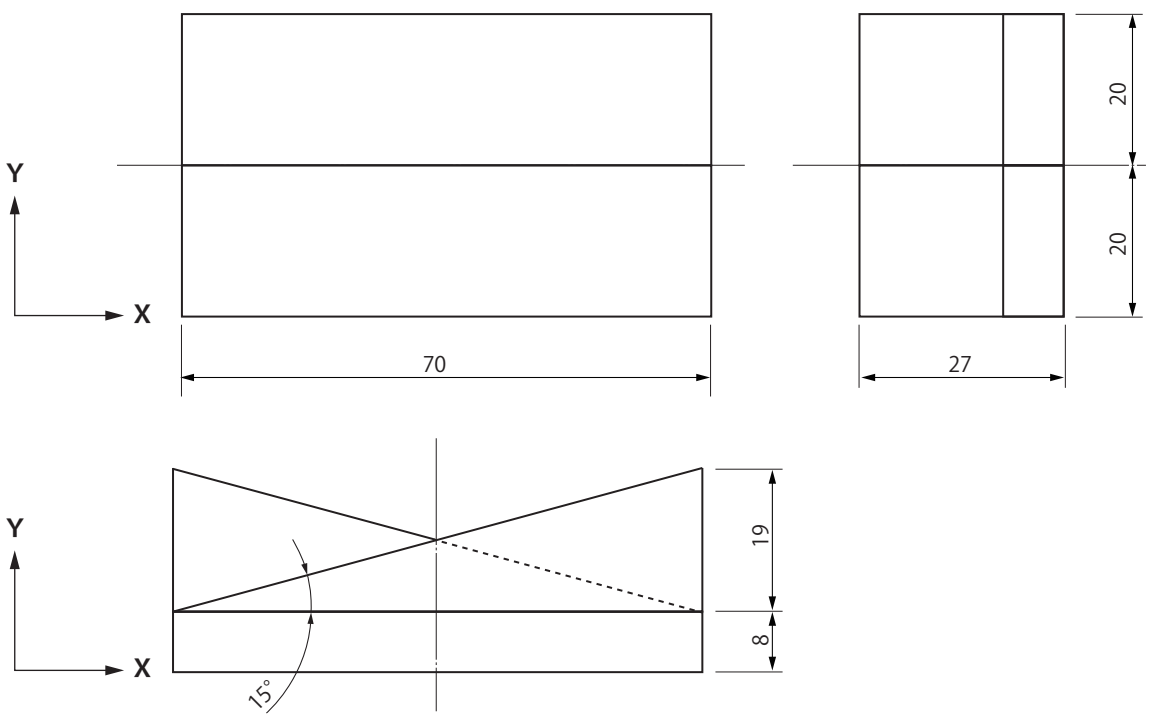
Specification of the phantom

Slice thickness section



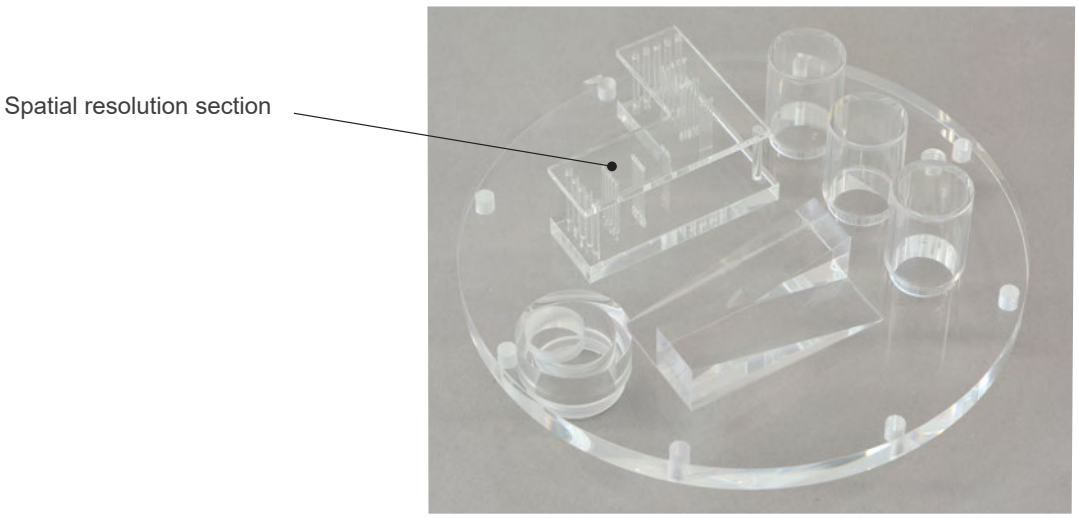
Structural design

unit mm

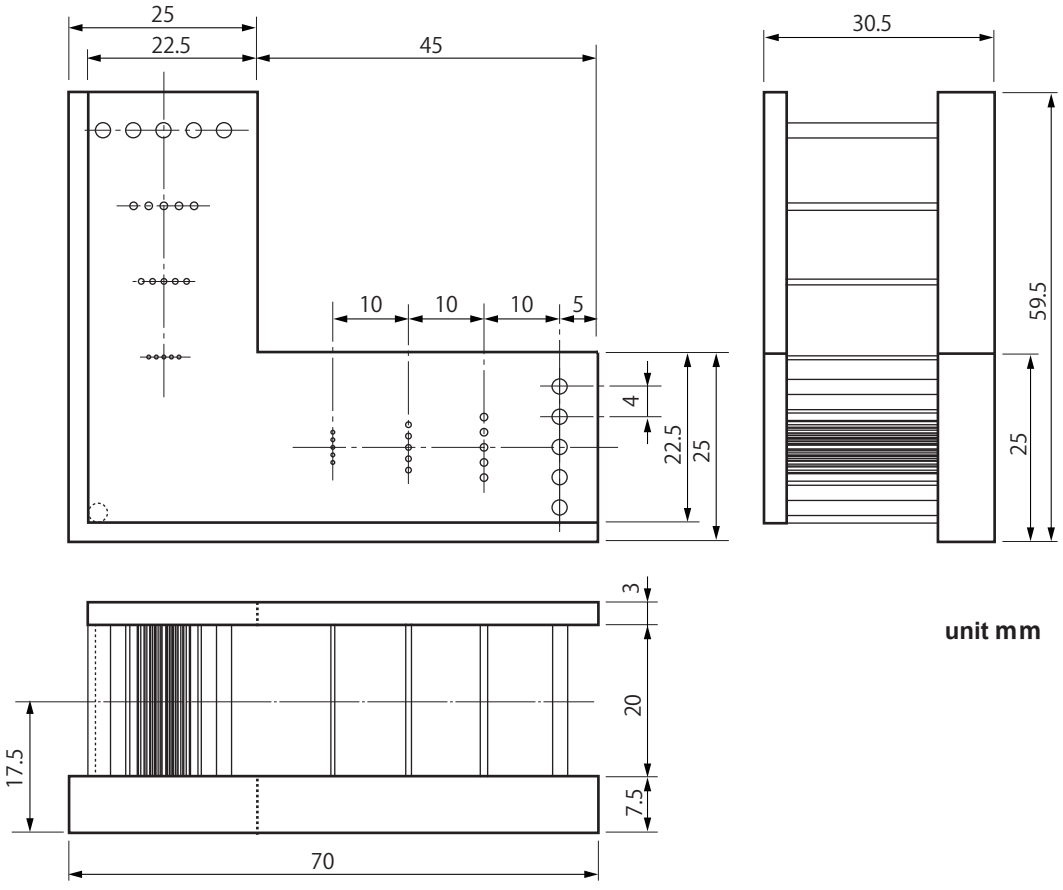


Specification of the phantom

Spatial resolution section



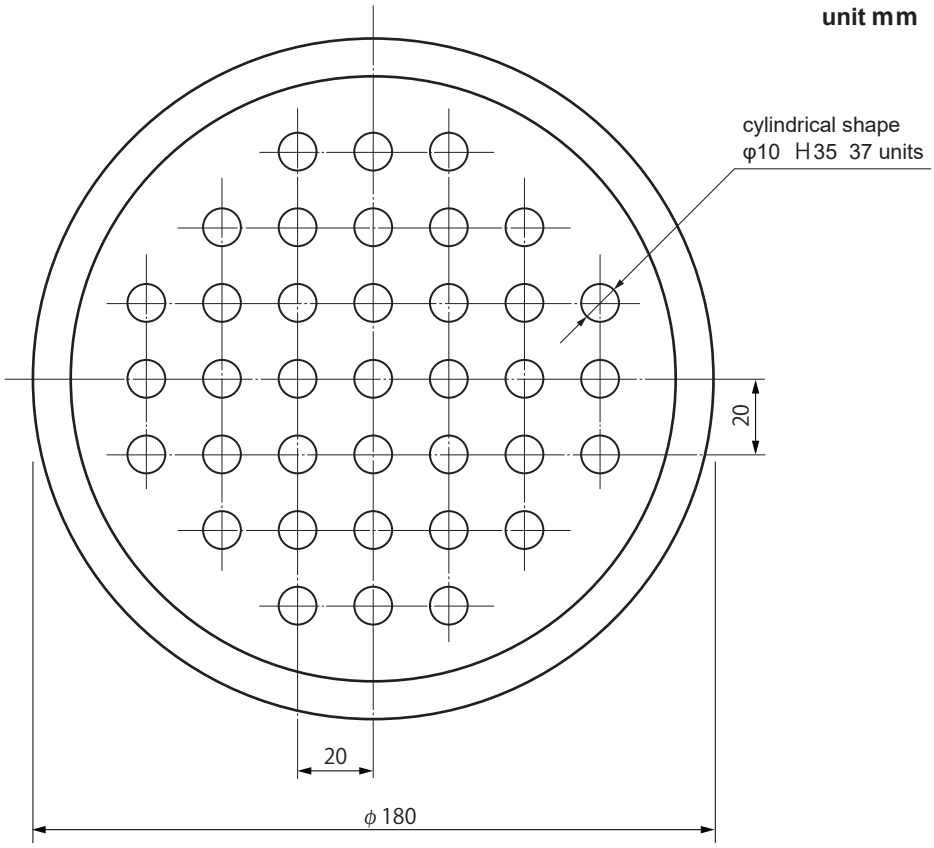
Structural design



Specification of the phantom

Geometric distortion section

Structural design

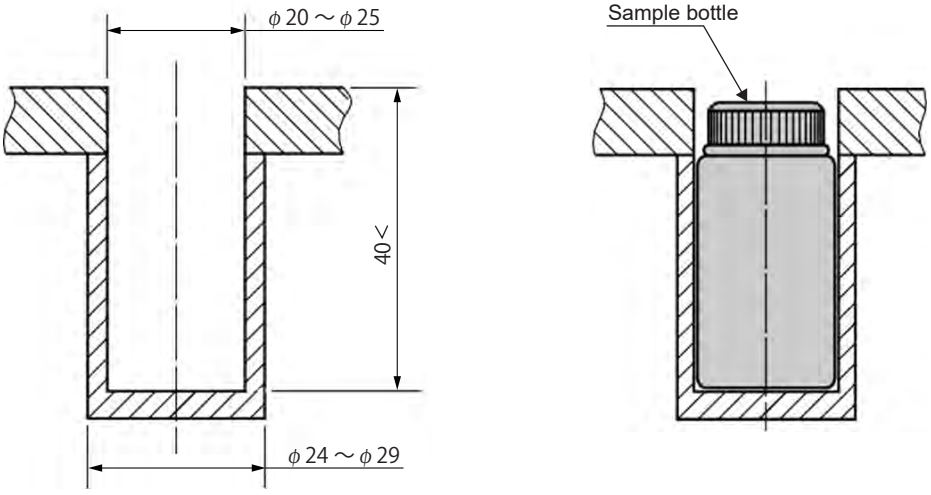


Specification of the phantom

Image contrast section (Sample bottle + holder)

Structural design

unit mm



Set-up

How to fill with MRI solution
Point to note during use

1 How to fill with MRI solution

1. In order to avoid leakages due to temperature changes, the phantom is not completely filled with the solution at the time of delivery. First, remove one of the two plastic caps from the main unit. Then insert the funnel into the hole to fill up the phantom by pouring the paraffin solution (c).

2. Use a pipette to fill up slowly the rest of the unit without leaving air bubbles inside. Afterwards close the port again with the plastic cap.

※ In order to avoid leakages due to temperature changes, remove the paraffin solution after use and return it to its' original liquid container (c).

2 Point to note during use

T1 and T2 values are heavily dependent on temperature changes; please take extreme care in maintaining a consistent temperature when the phantom is in use.
Leave the phantom with the contrast solution in room temperature for over 24 hours to retain a consistent temperature for the product.

The nickel dichloride solutions provided with the phantom are prepared after being stored for 24-hours in an environment with 23°C room temperature and a relative humidity of 40%.

1 How to use

● Cylindrical vessel arrangement

Position the phantom into the Radio-frequency coil according to common inspection procedures. To be able to maintain the same phantom position in routine inspections, methods as marking the cylindrical vessel should be used to ensure consistent and repeatable results. To prevent vortex artifacts, an appropriate amount of time (e.g. 15 minutes) should be waited between the placement of the cylindrical container and the start of imaging.

● Each evaluation parameter

○ Signal-to-noise-ratio (SNR)

[Caution]

The scans are performed in transverse, sagittal, and coronal planes with the imaging center aligned to ±20 mm of the isocenter. For measurements, two consecutive scans (Image 1 and Image 2) should be performed within 5 minutes from the end of the first scan to the beginning of the next scan. No adjustments or calibrations shall be done between the scans. The region of interest (ROI) is located at the center of a fixed geometric area - corresponding to at least 85% of the image volume range generated by the test device's signal. Through the difference calculus of the two scans the SNR can be obtained.

［See JIS Z 4952, 4.2.5 (Data analysis and tolerances).

[Evaluation]

The signal value shall be the calculated mean value in the ROI of the first and second image, respectively, and the standard deviation (SD) within the ROI of the subtracted image is determined. Divide SD by 2 and use this divided value as noise to measure SNR.

○ Image uniformity

[Caution]

The scans are performed in each transverse, axial, sagittal, and coronal planes with the imaging center aligned to ±20 mm of the isocenter. The dimensions and shape of the test apparatus shall at least include the specified area of the coil. Configurate ROI to include 85%of the signal range generated in the specified area.

The uniformity is determined from the average absolute deviation (AAD) of the signal on the ROI and the average of all pixel signal values in the ROI.

［See JIS Z 4952, 4.3.5 (Data analysis and tolerance).

[Evaluation]

Evaluate the coil sensitivity distribution from the uniformity.

1 How to use

○ Slice thickness
- Slice thickness phantom

[Caution]
Imaging is performed in transverse, axial and coronal planes with the imaging center aligned with the slice thickness phantom. Take measurements to ensure that the orientation of the phantoms aligns with the imaging slice. The alignment shall be confirmed by comparing the slice thickness measurements of the opposing wedge phantoms. The difference between the measured slice thicknesses of the opposing wedges should be less than 10%.
This method adopts the differential of the profile, but since this derivative operation increases the noise level of the slice profile, the required image SNR needs to be higher than 20.
The wedge method graphs the pixel intensity in the direction of the wedge slope. To obtain an expanded slice profile the graph of signal intensity is differentiated by distance. This is calculated by finding the difference in signal intensities of adjacent pixels and dividing by the distance between the pixels. Next, the slice thickness is determined as the product of the FWHM (Full width at half maximum) of the expanded profile and tan α.
[See A.3.2, (Alternative method: 2D slice thickness and slice profile: wedge method) of JIS Z 4952.]

[Evaluation]
To evaluate by the half width of the slice profile (slice thickness).
Note: Provided as one of the alternative test methods to the slice thickness measurement method using the inclined slab method.

○ Spatial resolution
- Spatial resolution phantom

[Caution]
The imaging is performed in transverse, axial, sagittal, and coronal planes with the imaging center aligned to ±10 mm of the spatial resolution phantom. By using a phantom with repeating patterns for evaluation, the image of a row of cylinders shall be visually observed, and whether each circle can be observed independently (resolved) in a row of cylinders of the same diameter shall be evaluated. It is recommended to have multiple people to evaluate.

[Evaluation]
Evaluate based on the diameter of the smallest cylinder that is resolved.

1 How to use

○ Geometric distortion

· Geometric distortion phantom

[Caution]

Imaging is performed in transverse, sagittal, and coronal sections with the imaging center aligned to ±15 mm of the Geometric distortion phantom. Distortion correction filters may be used for this test only. All other filters that may be selected by the operator should be disabled. If they cannot be disabled, all filters used should be listed in the results.

On each image obtained, measure the distance from the phantom center to the cylinder at a position corresponding to the guaranteed range of the device.

[Evaluation]

Calculate the error ratio between each measured value and the actual size of the phantom and evaluate the maximum error.

○ Ghost imaging

[Caution]

The phantom size shall not be greater than 50% of the image FOV (Field of View). The imaging is performed in transverse, sagittal, and coronal planes with the imaging center aligned within±20 mm of the isocenter. For each image taken, the average signal level within the phantom, the ghost signal level, and the noise standard deviation in the background region shall be measured. [See JIS Z952, 4.7 (Ghost Artifact)].

[Evaluation]

Measure the average signal value in the phantom using a ROI of at least 25 pixels. The ghost-to-signal ratio, ghost-to-noise ratio, and signal-to-noise ratio are determined and evaluated.

○ Image contrast

[Caution]

A cross-sectional image is taken with the center of the image aligned within ±20 mm of the measurement section. To obtain the desired relaxation times T1 and T2, paramagnetic ions are used to prepare a measurement fill of arbitrary concentration. Scans are taken under imaging conditions that provide the desired contrast, and the average signal level and noise standard deviation within the sample are measured.

[Evaluation]

Set ROI is within each sample, and evaluate the contrast by using the average signal value and noise.

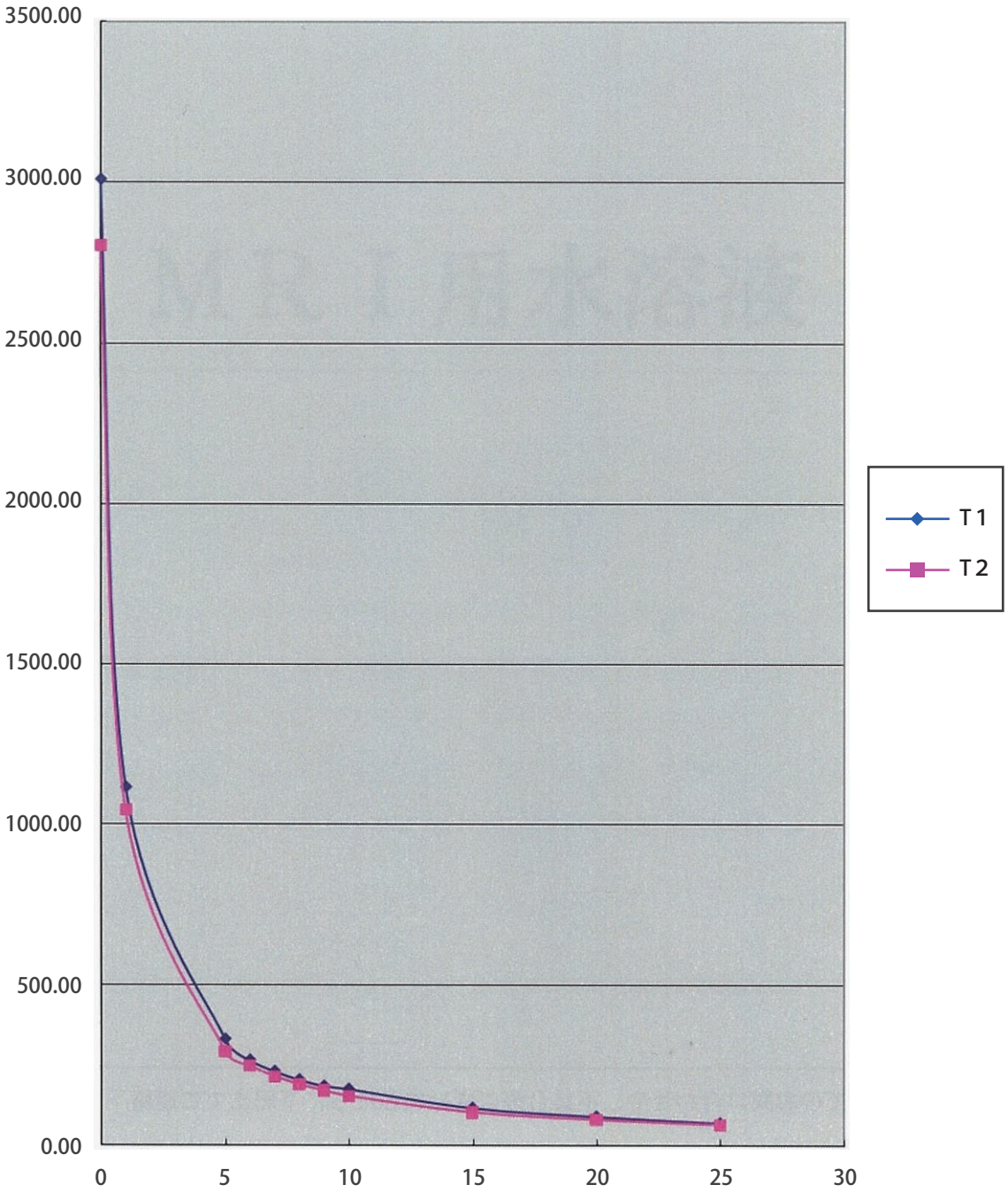
References

$NiCl_2$ density (mM)	1	5	6	7	8
T1 value (msec)	1117	329	264	229	203
Standard deviation	23.53	5.54	10.11	4.5	3.02
T2 value (msec)	1044	291	246	213	189
Standard deviation	6.96	0.83	0.56	0.61	0.66
$NiCl_2$ density (mM)	9	10	15	20	25
T1 value (msec)	184	174	116	89	69
Standard deviation	4.28	2.11	1.27	1.03	0.71
T2 value (msec)	169	152	102	79	64
Standard deviation	0.51	0.65	0.5	0.11	0.4

T1 and T2 values of the magnetic resonance of varying nickel dichloride densities

※ Data taken at 24°C room temperature and 1.5 Tesla magnetic field strength

References



T1 and T2 values of varying nickel dichloride densities

Filler for 3 Tesla-compatible MRI phantoms

National Cancer Center Japan, Main Hospital Research Center

Uniformity measurement

Uniformity

	Water soluble filler	New filler
1.5 Tesla	17.7%	8.2%
3 Tesla	49.6%	7.4%

The uniformity of the 3 Tesla water soluble filler was 49.6%, other results were within 20%.

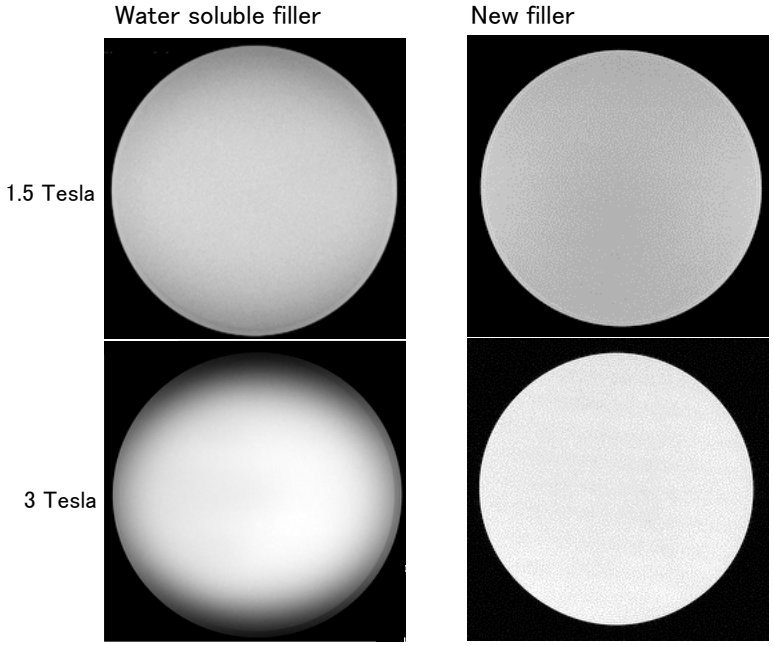


Fig.1 Comparison of uniformity

The uniformity of the 3 Tesla water soluble filler is non-uniform with differences in signal intensity at the edges and in the center.

Uniformity imaging conditions

3 Tesla
Spin Echo Temperature = 23°
TR = 1500ms TE = 14ms
NEX = 1 FA = 75°
Scan Time = 6:26
FOV = 25×25cm
Matrix size = 256×256
BW = 130Hz/px
Slice thickness = 6.0mm
Coil = Whole Body Coil

The imaging conditions for the 1,5 Tesla system, are the same as for the 3 Tesla.

T1, T2 value measurement

T1 value

	Water soluble filler	New filler
1.5 Tesla	161ms	206ms
3 Tesla	173ms	241ms

T2 value

	Water soluble filler	New filler
1.5 Tesla	145ms	105ms
3 Tesla	121ms	89ms

New filler T2 value ＞ 50ms

T1 value imaging condition

3 Tesla
FSE - IR Temperature = 23°
TI = 50, 75, 100 ・・・・ 2000, 2500ms
TR = 3000ms TE = 10ms NEX = 1 FA = 170°Scan Time = 1:50 FOV = 25×25cm
Matrix size = 256×192 BW = 180Hz/px
Slice thickness = 5.0mm Coil = Whole Body Coil

T2 value imaging condition

3 Tesla
SE Multi Echo Temperature = 23°
TR = 3000ms NEX = 1 FA = 180°
Scan Time = 9:41 TE = 22, 44, 66, ・・・・ 330, 352ms
FOV = 25×25cm Matrix size = 256×192
BW = 130Hz/px Slice thickness = 6.0mm
Coil = Whole Body Coil

The imaging conditions of the 1.5 Tesla system were set to be equivalent.

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