



ACR  
 ACR  
 가 148 mm, 190 mm  
 10 mM NiCl<sub>2</sub> 75 mM NaCl  
 (Fig. 1).  
 가  
 ‘CHIN’ 가  
 가  
 ‘NOSE’  
 DICOM  
 3 가  
 가 20 7 가  
 3  
 . ACR  
 (sagittal localizer) (Fig. 2).  
 11 4  
 가  
 ACR T1 T2  
 ACR  
 (Table 1). 3 ( A, D,  
 E) ACR  
 ACR

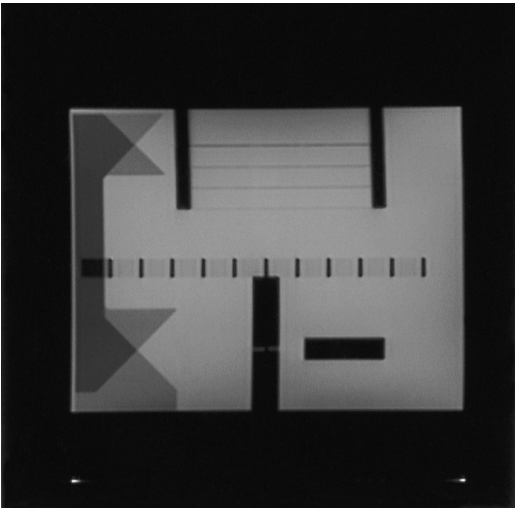


Fig. 2. Sagittal localizer image of ACR phantom.

Table 1. ACR Pulse Sequence Acquisition Parameters

Image	TR(ms)	TE(ms)	Matrix	FOV(cm)	Slice Thickness(mm)	Gap(mm)	NEX
Sagittal Localizer	200	20	256 × 256	25	20		1
T1 Spin Echo	500	20	256 × 256	25	5	5	1
T2 Spin Echo	2000	20/80	256 × 256	25	5	5	1

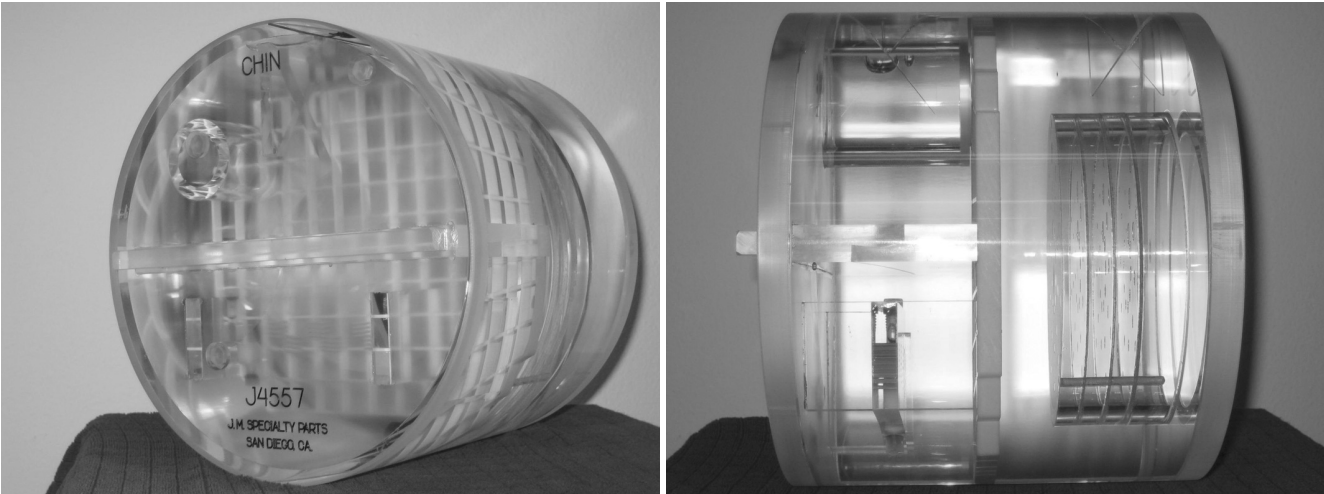


Fig. 1. Oblique (A) and lateral (B) views of ACR phantom.

DICOM , DICOM  
가  
가 . ACR  
7가  
가 .  
(window level) ACR  
(window width)  
가가  
.  
.  
(Geometric accuracy)  
가  
가  
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ACR T1 #1 #5  
(Fig. 3).  
148 mm  
3 mm 가 . ACR T1  
#1 #5  
190 mm 3 mm  
가 .  
(High contrast spatial resolution)  
가 가  
가  
.  
ACR T1 ACR T2 #1  
가 3  
(Fig. 4A).  
mm, 0.9 mm , 1.1 mm, 1.0  
. 4 , 4  
가 , 4  
4 가  
(Fig. 4B). 1.0 mm 가

(Slice thickness accuracy)

가

가

가

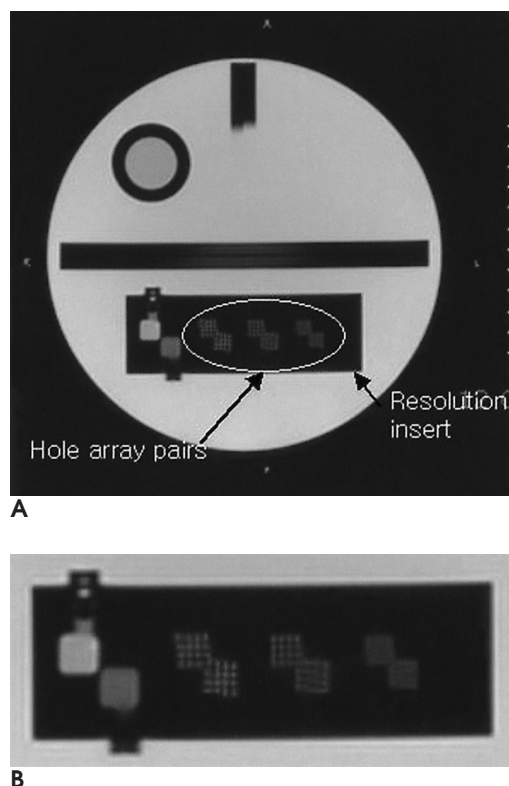
(Fig. 4A)

(Fig. 5).

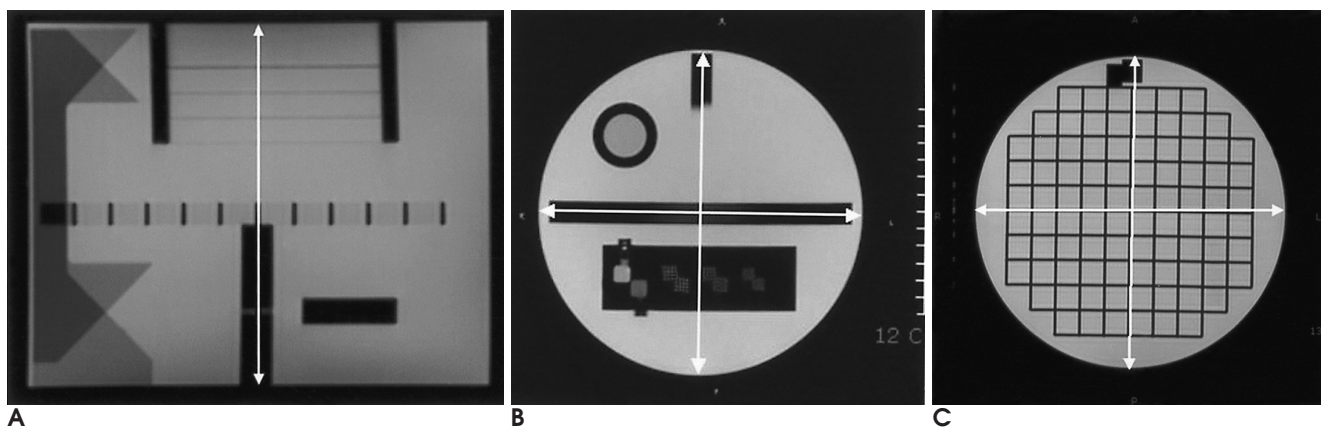
5 mm

0.7 mm

가



**Fig. 4. A.** Slice 1 with resolution insert and hole array pairs indicated.  
**B.** Magnification view of high contrast resolution insert from slice 1 shows three sets of two arrays of holes.



**Fig. 3. A.** Positioning of length measurement on sagittal localizer (arrow). **B.** Slice 1 with diameter measurements illustrated (arrows). **C.** Position for diameter measurements on slice 5 (arrows).

(Slice position accuracy)

가 . ACR

T1 T2 #1 #11

가 .

5 mm

가

(Fig. 6).

(Image intensity uniformity)

가 . ACR T1 T2 #7

가

195 - 205 cm<sup>2</sup>

(Fig. 7)

가 가

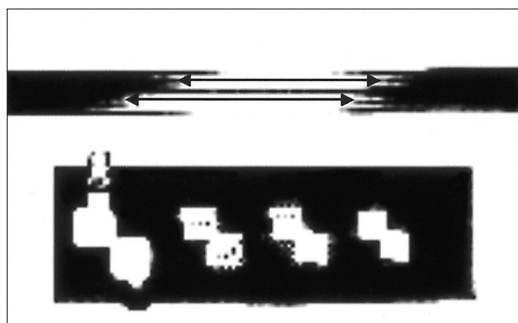
(Percent integral uniformity; PIU) 87.5%

가 .

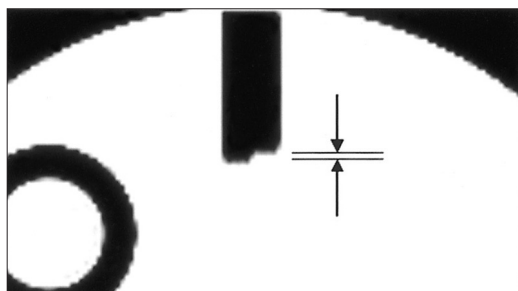
(Percent signal ghosting)

ACR T1 #7 . 가

195 - 205 cm<sup>2</sup>



**Fig. 5.** Magnified portion of slice 1 showing slice thickness signal ramps. The length measurements for the ramps are shown on the image (arrows).



**Fig. 6.** Magnified portion of slice 1 illustrating slice position error. The arrows indicate the bar length difference measurement.

ACR

(Fig. 7)

10 cm<sup>2</sup>

(Fig. 8)

0.025

가 .

(Low contrast object detectability)

가 가

#8

10

3 가

가

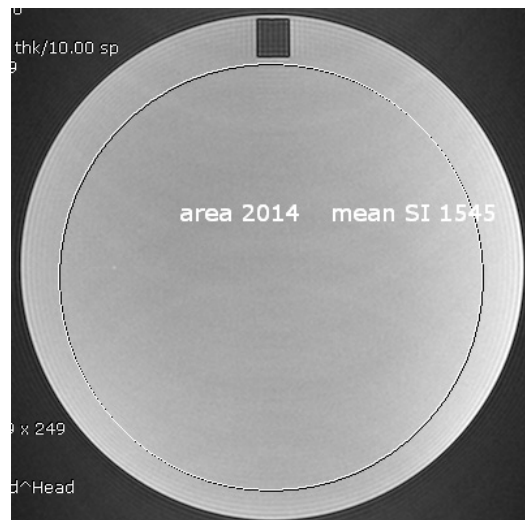
(Fig. 9).

가 , #11

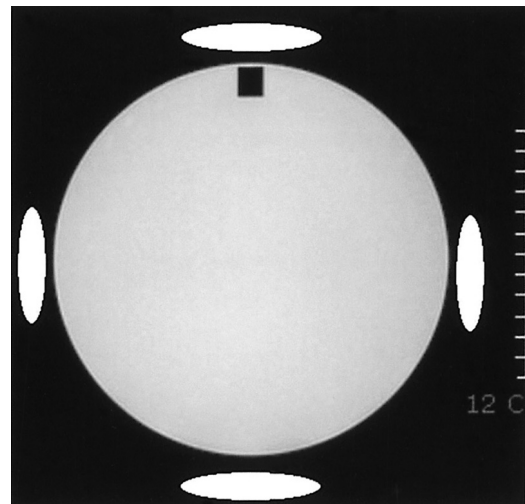
가 . 3

4

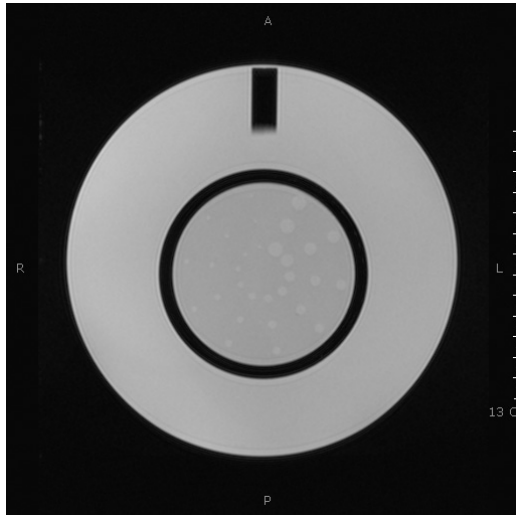
가 9



**Fig. 7.** Image of slice 7 showing size and placement of the large ROI.



**Fig. 8.** Image of slice 7 illustrating four small ROIs placement.



**Fig. 9.** Image of slice 11 showing the circles of low contrast objects.

### Table 2. MRI Instruments

Symbol	Site*	Year Manufactured	MR Manufacturer	Magnetic field strength(Tesla)
A	3	2004	Ailab	0.3
B	3	1998	Toshiba	1.5
C	3	2000	Medison	1.0
D	2	1996	Fornor	0.35
E	2	1995	Picker	1.0
F	2	1997	Toshiba	1.5
G	1	1997	Picker	1.5
H	1	1994	Siemens	1.0
I	4	2003	GE	1.5
J	1	2002	GE	3.0
K	1	2003	GE	1.5
L	1	1997	Siemens	1.5
M	2	2001	Hitachi	0.3
N	3	2002	Isol	0.3
O	1	2000	GE	1.5
P	1	1995	GE	1.5
Q	1	1995	GE	1.5
R	4	1997	Medinus	1.5
S	4	1997	Elscint	0.5
T	2	2003	Hitachi	0.3

\* 1: University hospitals, 2: General hospitals, 3: Hospitals,  
4: Local clinics  
GE: General electric

가 .

S      4      1997      Elscint      0.5  
T      2      2003      Hitachi      0.3

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\* 1: University hospitals, 2: General hospitals, 3: Hospitals,  
4: Local clinics  
GE: General electric

ACR

8 ,      5 ,      4 ,      3  
(Table 2).      0.5 T (tesla) - 36.8%      . 2 mm  
6 , 1.0 T 4 , 1.5 T 9 , 3 T 가 1  
11 .      가      가  
3 mm  
10.5% - 21.1%

가 .      2      가      1.0 mm  
가      가 20      3 .  
3      4  
30      1      가      . 1      7      6      3  
DICOM      CD-ROM      4      .      3      4  
13      가      7가      가      Table 3      가      5      가      가  
DICOM      가      /      가      ( K )      가      가  
가      ,      (multichannel)  
가      ACR      6      K가  
1      ACR      2      2      #8  
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**Table 3.** Results of MRI Phantom Test

Test	Slice	Item	Normal Range	Mean	Test Instruments (No.)	Failed Instruments (No.)	Failure Rate (%)
Geometric accuracy	Localizer	End-to-End	145 - 150 mm	146.95	19	2	10.5
	ACR T1 #1	Top-to-Bottom	187 - 193 mm	190.07	19	3	15.8
		Left-to-Right		189.79	19	3	15.8
	ACR T1 #5	Top-to-Bottom		189.70	19	4	21.1
		Left-to-Right		189.68	19	2	10.5
High contrast spatial resolution	ACR T1 #1	Left-to-Right	1.0	0.99	20	2	10.0
		Top-to-Bottom		1.00	20	2	10.0
	ACR T2 #1	Left-to-Right		1.01	20	3	15.0
		Top-to-Bottom		1.01	20	3	15.0
Slice thickness accuracy	ACR T1 #1	Slice thickness	4.3 - 5.7 mm	5.24	18	4	22.2
	ACR T2 #1	Slice thickness		4.94	18	1	5.6
Slice position accuracy	ACR T1 #1	Length difference	5 mm	2.99	19	2	10.5
	ACR T1 #11	Length difference		2.17	19	1	5.3
	ACR T2 #1	Length difference		2.80	18	3	16.7
	ACR T2 #11	Length difference		2.09	18	3	16.7
Image intensity uniformity	ACR T1 #7	PIU	87.5	94.74	17	1	5.9
	ACR T2 #7	PIU		93.43	16	1	6.3
Percent signal ghosting	ACR T1 #7	Ghosting ratio	0.025	0.016	19	3	15.8
Low contrast object	ACR T1	#8 - #11	9	27.03	12	1	8.3
	ACR T2	#8 - #11		25.53	12	1	8.3
detectability	Site T1	#8 - #11		29.07	10	1	10.0
	Site T2	#8 - #11		24.62	10	1	10.0

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ACR: American College of Radiology

PIU: Percent integral uniformity

**Table 4.** Inter-Observer Variation

Test	Slice	Item	Measurements Variation ( <i>p</i> Value)	Failure Variation ( <i>p</i> Value)
Geometric accuracy	Localizer	End-to-End	0.521	1.000
		Top-to-Bottom	0.999	0.844
		Left-to-Right	0.850	1.000
	ACR T1 #5	Top-to-Bottom	0.983	0.858
		Left-to-Right	0.520	0.800
High contrast spatial resolution	ACR T1 #1	Left-to-Right	0.908	1.000
		Top-to-Bottom	1.000	0.409
	ACR T2 #1	Left-to-Right	0.678	0.844
		Top-to-Bottom	0.678	0.844
Slice thickness accuracy	ACR T1 #1	Slice thickness	0.928	0.502
	ACR T2 #1	Slice thickness	0.788	1.000
Slice position accuracy	ACR T1 #1	Length difference	0.851	0.844
	ACR T1 #11	Length difference	0.971	0.762
	ACR T2 #1	Length difference	0.973	0.858
	ACR T2 #11	Length difference	0.971	1.000
Image intensity uniformity	ACR T1 #7	PIU	0.833	0.997
	ACR T2 #7	PIU	0.762	0.580
Percent signal ghosting	ACR T1 #7	Ghosting ratio	0.675	0.656
Low contrast object detectability	ACR T1	#8-#11	0.913	1.000
	ACR T2	#8-#11	0.767	1.000

가 (17). ACR

. 1990

European Economic Communities

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가 (signal - to - noise ratio), (contrast - to - noise ratio), (9).

가 (4, 5, 17).

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1990 (American Association of Physicists in Medicine; AAPM)

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1. *MRI*

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5. Chen CC, Wan YL, Wai YY, Liu HL. Quality assurance of clinical MRI scanners using ACR MRI phantom: preliminary results. *J Digit Imaging* 2004;17:279-284

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16. . (MRI) 가  
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17. American College of Radiology. *Phantom test guidance for the ACR MRI accreditation program*. Reston: American College of Radiology. 2000

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## Usefulness of ACR MRI Phantom for Quality Assurance of MRI Instruments<sup>1</sup>

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<sup>4</sup>Department of Electronics and Information Engineering, Korea University

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**Purpose:** To examine whether the ACR phantom could be used in quality standards for magnetic resonance imaging (MRI) instruments in Korea.

**Materials and Methods:** We conducted the phantom test using the ACR MRI phantom in 20 MRI instruments currently used in Korea. According to ACR criteria, we acquired the phantom images which were then assessed by the following seven tests: geometric accuracy, high spatial resolution, slice thickness accuracy, slice position accuracy, image intensity uniformity, percent signal ghosting, and low contrast object detectability. The phantom images were interpreted by three experienced radiologists according to ACR criteria. Then, we examined the failure rate of each test and evaluated the inter-observer variation in the measurements and test failure.

**Results:** The failure rate of each test could be broken into the following components: geometric accuracy (11 - 21%), high contrast spatial resolution (10 - 15%), slice thickness accuracy (6 - 22%), slice position accuracy (5 - 17%), image intensity uniformity (6%), percent signal ghosting (16%), and low contrast object detectability (8 - 10%). In this series, all the failure rates were less than 30%. In addition, no inter-observer variation was seen in the measurements and test failure.

**Conclusion:** ACR MRI phantom promises to be established as the standard phantom for MRI instruments in Korea because of its objectivity in assessing the phantom images.

**Index words :** Magnetic resonance (MR), quality assurance  
Phantoms

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