The44th JSMRM in Saitama

Friday , Sep 9 , 2016

~ Part.2 ~
Application experiment of electromagnetic wave protective clothing for capsule endoscopy in MRI head area scans
「第2法　頭部MRI領域におけるカプセル内視鏡用電磁波防護服の応用」

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☑ The author has no conflict of interest to with respect to this presentation

Background

- ✓ The body metal device, such as cardiac pacemaker, ICD, heart stents, metal implants and so on, may lead to opportunity loss of useful diagnostic benefit of MRI examination.

Purpose

- ✓ We focused on the usefulness of silver fibers in the MRI.
- ✓ We investigated the effect of shielding from RF wave used in MRI other than the head by using the Endoscope capsule electromagnetic wave protective clothing and Head-Neck Phantom.

*This capsule endoscope electromagnetic wave protective clothing is made of double sheets of EMC (silver sheet) used in Part 1.

Materials

- MRI
  - ・GE Co. SignaHDxt 1.5T
  - ・SIEMENS Co. Magnetom Skyra 3.0T
- COIL
  - ・GE Co. HD Body Array Coil
  - ・SIEMENS Co. Body18 , Spine 32
- PHANTOM
  - ・GE Co.8chNVA Phantom, SNR Phantom Square
  - ・SIEMENS Co. Wrist/Hand Phantom 1100ml
- ELECTROMAGNETIC WAVE SHIEDING MATERIAL
  - ・MEDICAL-AID,Inc. MG Vest CES
    (Endoscope capsule electromagnetic wave protective clothing)

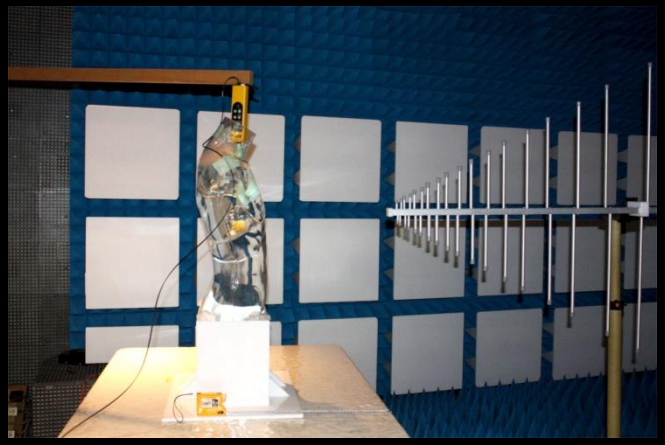
Method

1. The center of the head-neck phantom was set for the center of the neck.
2. The center of the head-neck phantom was arranged so as to match the center of the magnetic field.
3. Covered the head-neck phantom with the capsule endoscope protective clothing..

   *Consideration had to be given so that there is no gap.
4. By using of a T1 weight fast SE method, sagittal images and coronal images were taken for phantom center.

Method

5. Those images were taken by 1.5T MRI and 3.0T MRI under the same conditions.
6. SNR and sensitivity distribution was measured by using image analysis software.
7. Confirmed the correlation between the results of **the electromagnetic wave attenuation effect judgment test** and the results of image analysis.



August 22, 2016
The electromagnetic wave attenuation effect judgment test was measured at Technology Research Institute of Osaka Prefecture.

Figure.8
Anechoic chamber test protector(-)

- ✓ Inserted the measuring instrument "probe" into the human body phantom which was filled with tissue equivalent material 0.18% NaCl solution.
- ✓ Irradiated the human body Phantom respectively by 64MHz or 128MHz radio waves (200W) from 500mm away antenna in horizontal distance.
- ✓ Measured the electric field strength by wearing or not wearing the protective clothing.

Conditions of measurement in MRI

1. Room temperature 20 ℃
2. Imaging was performed in triplicate.
3. Measurement interval for preparation of each set of shielding materials was at least 10 minutes.

Imaging parameter of each T1W imaging technique

Sequence parameter	T1 Weighted Image			
MRI Unit	Siemens Skyra3.0T		GE signaHDx1.5T	
Pulse Sequense	2D-Quiet TSE		2D-FSE XL	
Sacning orientation	Sagittal	Coronal	Sagittal	Coronal
Field of view(FOV)(mm)	400		400	
Matrix	256*256		256*256	
Slice thickness(mm)	10		10	
Repetition time(TR)(ms)	600		600	
Echo time(TE)(ms)	20	24	20	24
PAT mode	GRAPPA		ASSET2.0	
Band width	300(Hz/Px)	201(Hz/Px)	80(MHz)	128(MHz)
TSE factor	3		3	
Flip angle(deg)	150		90	
Phase enc.dir	F>>H	R>>L	F>>H	R>>L
FOV phase(%)	100	100		
Averages	1	1	2	2
Coil elements	Body123,Spine123		HD/Body Full	
Filter	Prescannormalize medium Distotion corr		PURE	

Figure.4 1.5T Control

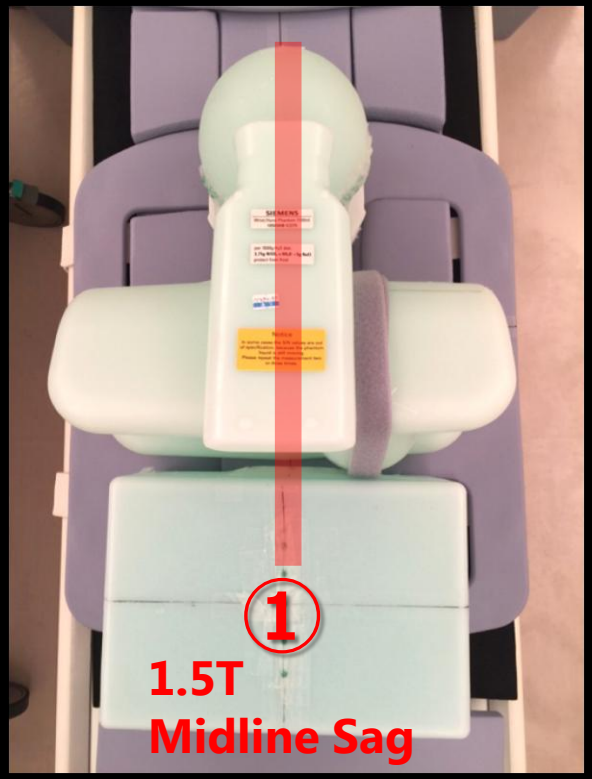


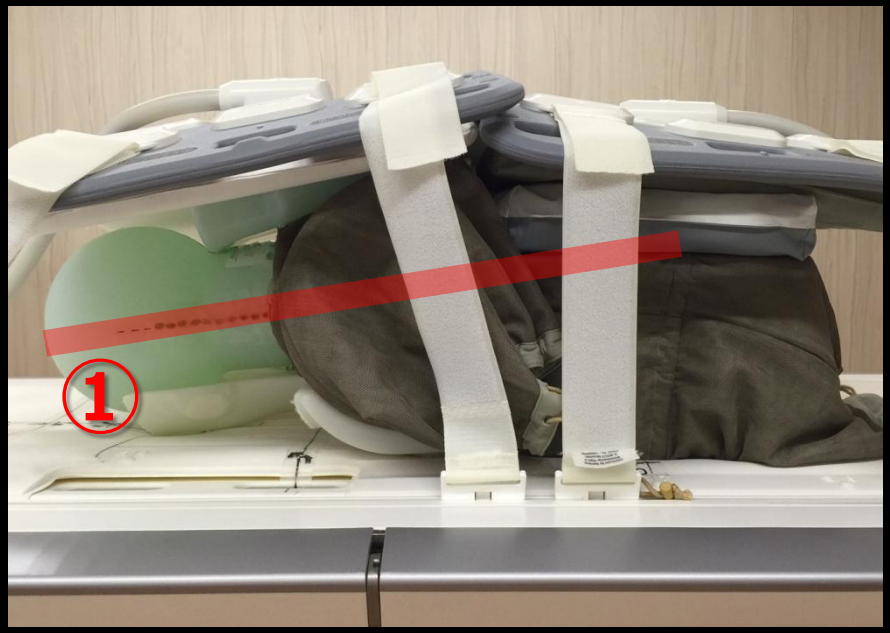
Figure.5 3.0T Shield(++)

- Put on the phantom with the capsule endoscope protective clothing. One to two clothing usage.
- Highlight ① is a cross-sectional image of sagittal images.

① : Midline sagittal image

Figure.6　1.5T Control

Figure.7　3.0T Shield(++)



- Wrist-hand phantom placed on top of the head-neck Phantom.
- Highlight ① is a cross-sectional image of coronal images.

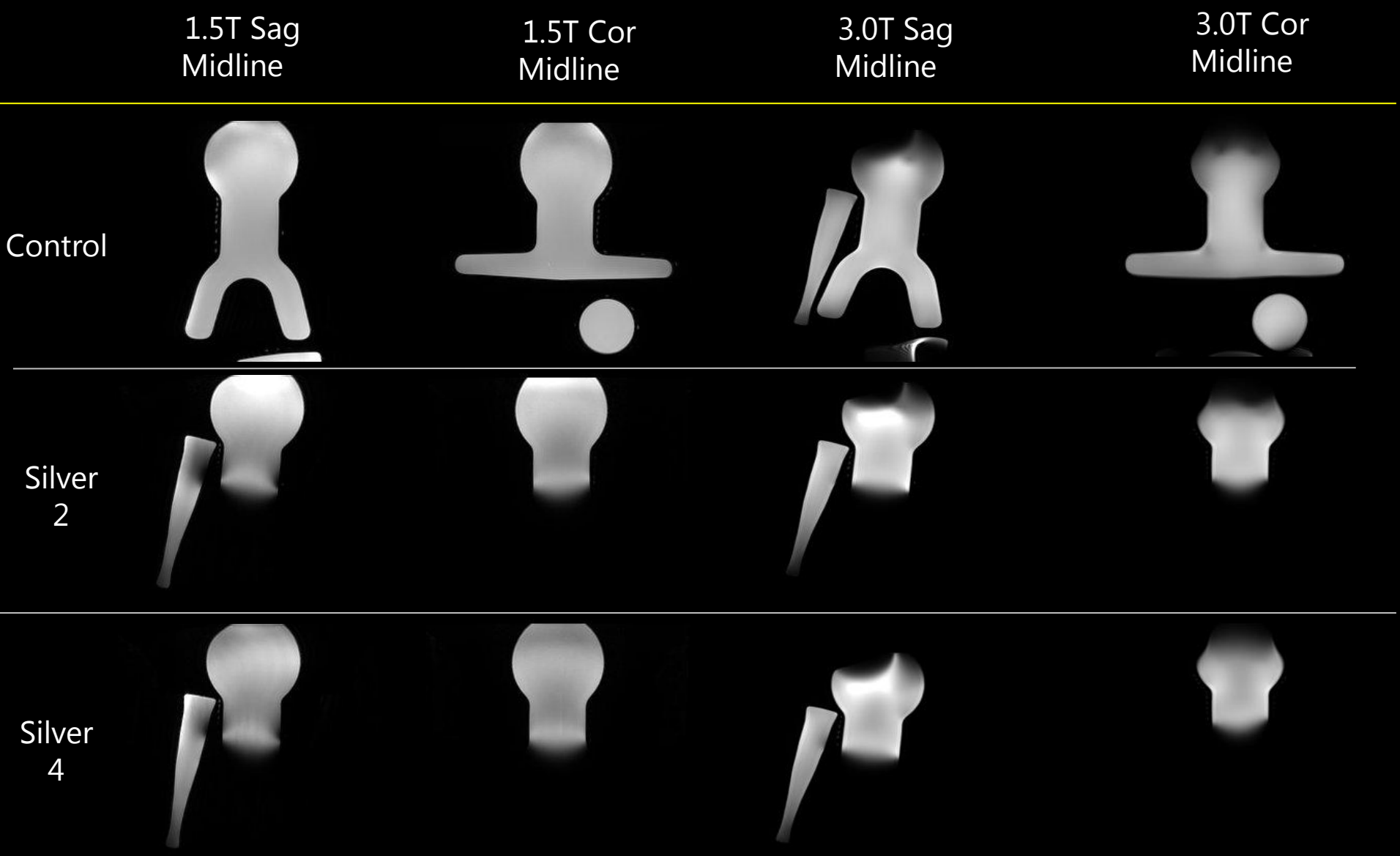
① : Midline coronal image

Contents of study

1. **Sensitivity distribution** (RF wave attenuation curve)
2. **SNR** SNR（ROI2）＝Mean（avg.）/SD(avg.)
3. **In the correlation with the electromagnetic wave attenuation effect judgment test**

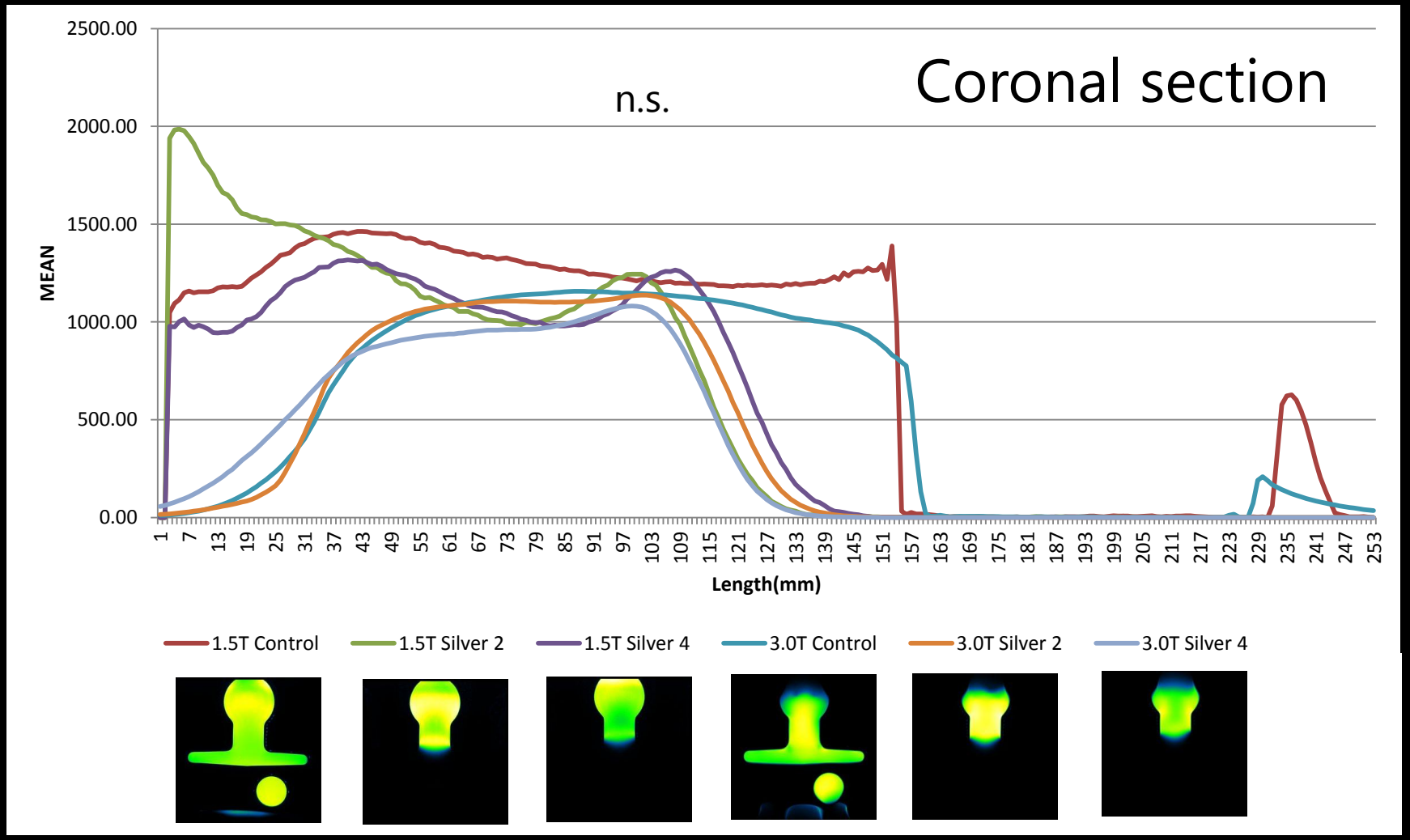
Analyzed by image analysis software (Image J)

Results

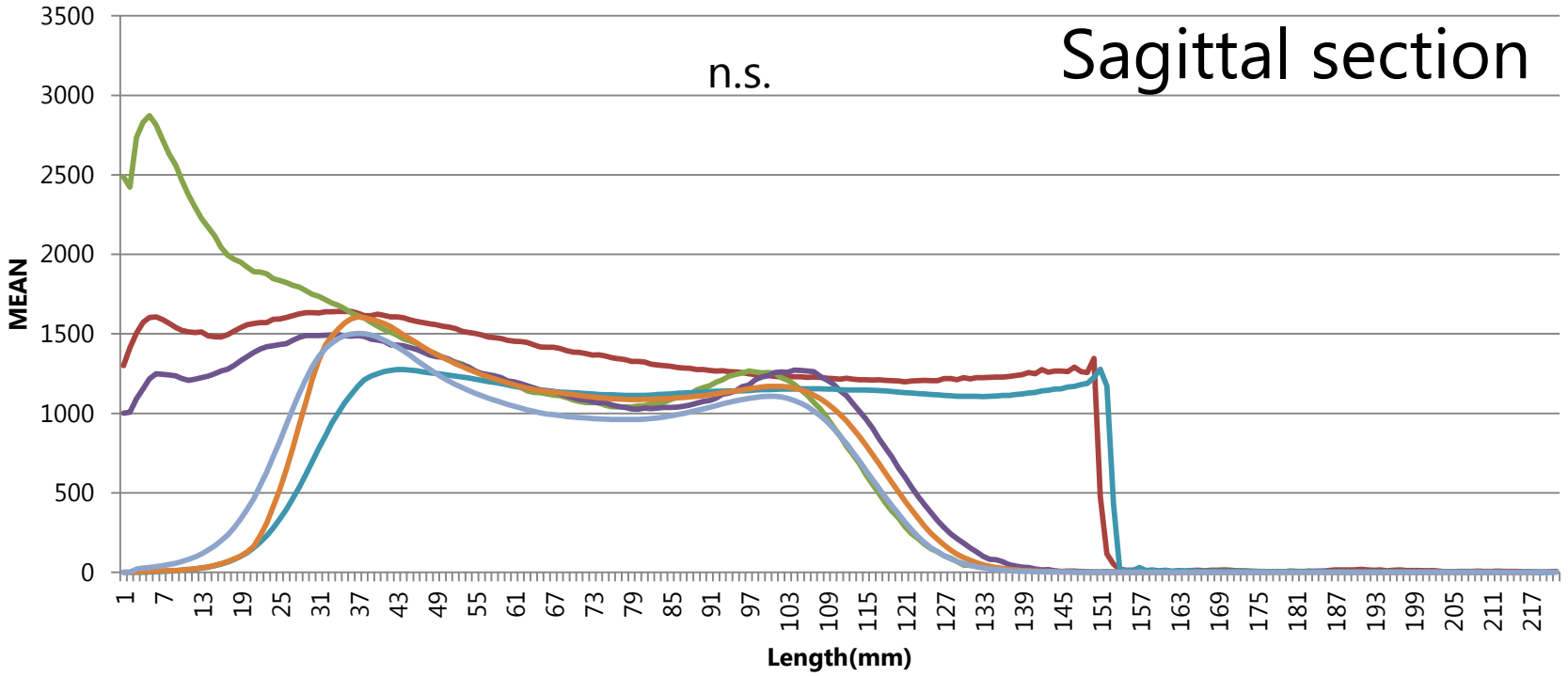


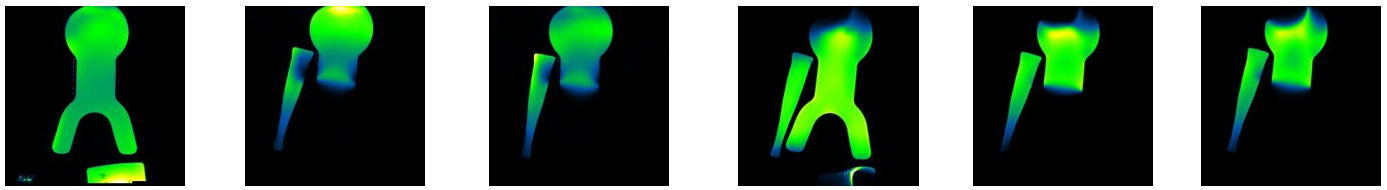
By using a T1 weight fast SE method, Sagittal image and Coronal image were taken.

Sensitivity distribution in the Coronal image of 3.0T(128MHz) and 1.5T (64MHz) (RF wave attenuation curve)

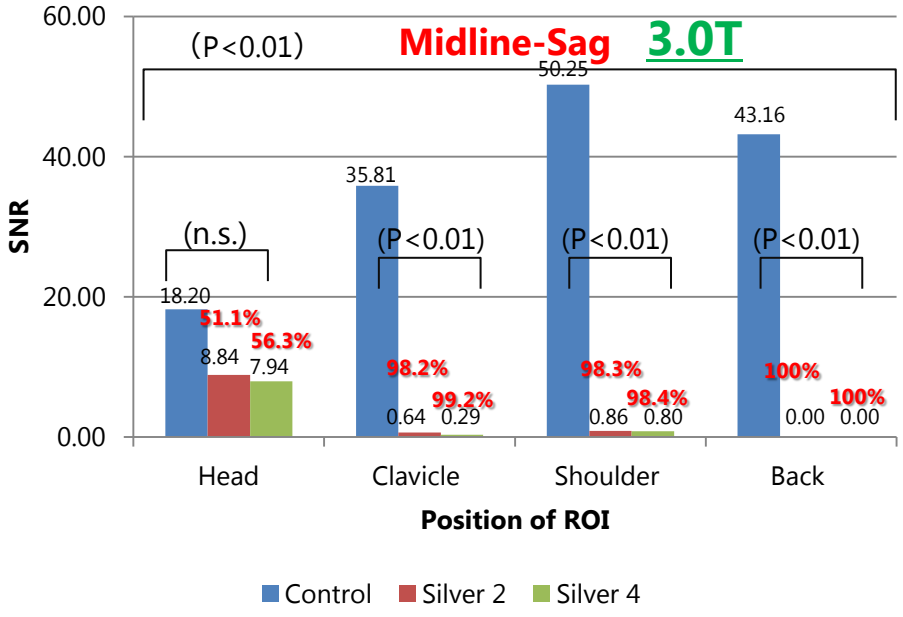


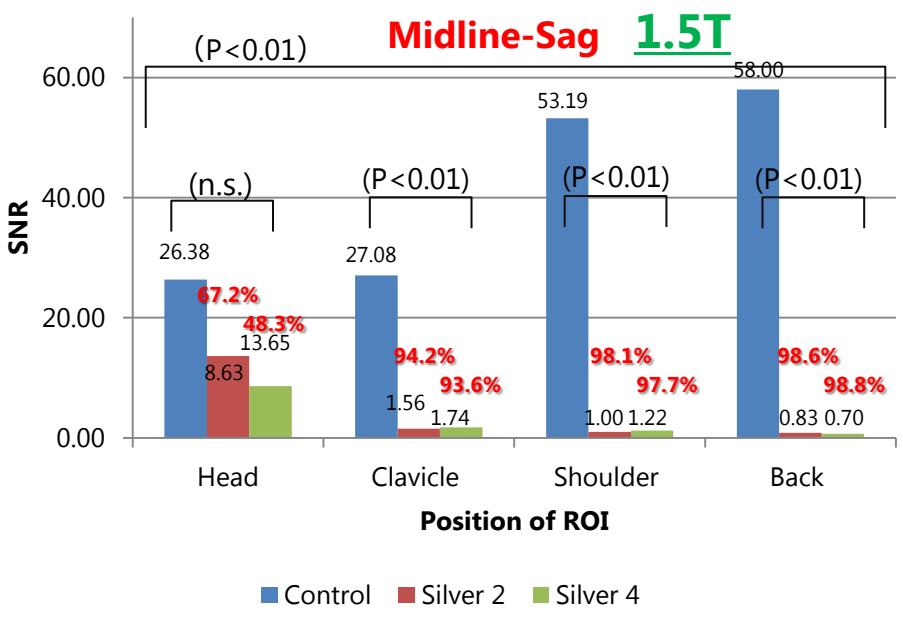
Sensitivity distribution in the Sagittal image of 3.0T(128MHz) and 1.5T (64MHz) (RF wave attenuation curve)



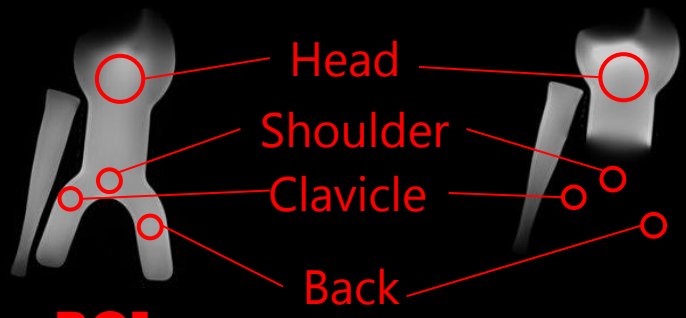


Comparison of SNR of each ROI of the phantom in 3.0T (128MHz) and 1.5T (64MHz)





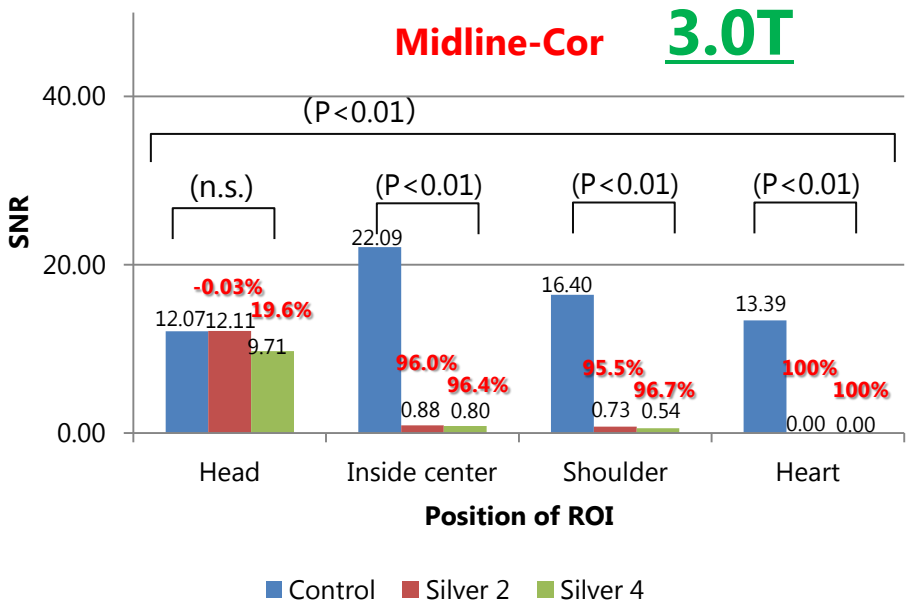
1.5T Midline-Sag

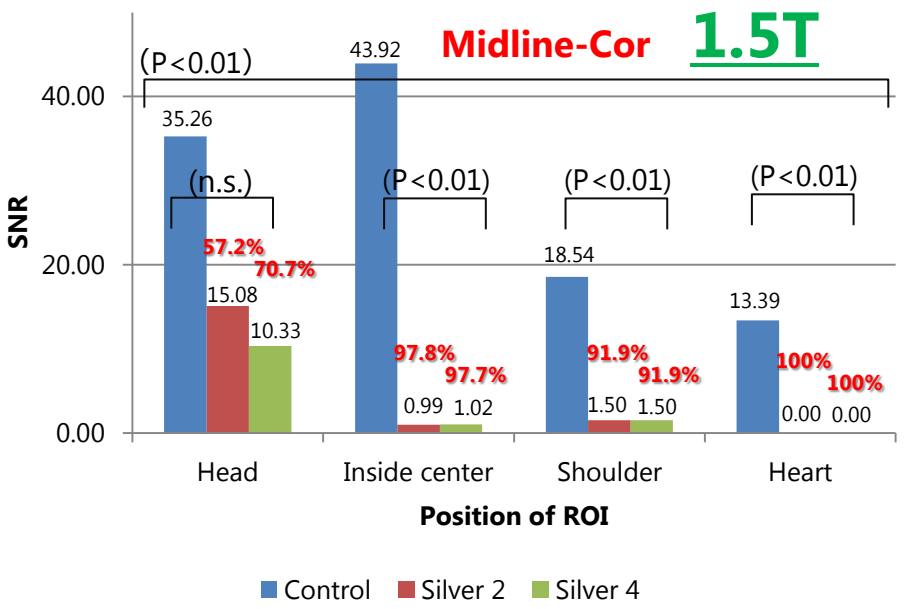


ROI

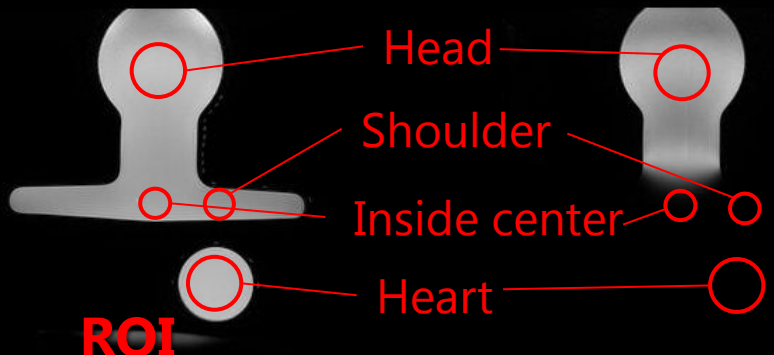
3.0T Midline-Sag

Comparison of SNR of each ROI of the phantom in 3.0T (128MHz) and 1.5T (64MHz)





1.5T Midline-Cor



3.0T Midline-Sag

Electromagnetic wave attenuation effect judgment test results (128MHz/64MHz) in inside of the body phantom

- **128MHz = 78.39%(ave.)**

Inside of the body phantom													
		Vertical 0 degree				Cranial +30 degrees				Caudal -30 degrees			
		No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)
Angle around (degree)	0	47.67	10.68	77.60%	12.99dB	44.20	9.85	77.71%	13.04dB	45.80	11.47	74.95%	12.02dB
	45	48.22	9.14	81.05%	14.45dB	45.97	9.85	78.56%	13.38dB	48.96	9.18	81.24%	14.54dB
	90	46.73	9.22	80.27%	14.1dB	46.07	8.37	81.83%	14.82dB	44.30	9.60	78.32%	13.28dB
	135	40.79	8.88	78.24%	13.25dB	43.50	8.16	81.25%	14.54dB	45.53	11.45	74.84%	11.99dB
	180	38.10	8.50	77.70%	13.03dB	34.30	8.16	76.22%	12.48dB	43.59	11.29	74.09%	11.73dB
	225	38.02	8.29	78.20%	13.23dB	33.05	7.99	75.82%	12.33dB	42.84	9.96	76.75%	12.67dB
	270	43.95	8.24	81.24%	14.54dB	41.00	7.78	81.02%	14.43dB	49.19	10.00	79.68%	13.84dB
	315	46.91	9.92	78.86%	13.5dB	45.42	9.20	79.74%	13.87dB	50.73	12.08	76.19%	12.47dB
Ave.		43.80	9.11	79.14%	13.64dB	41.69	8.67	79.02%	13.61dB	46.37	10.63	77.01%	12.82dB

- **64MHz = 78.97%(ave.)**

Inside of the body phantom													
		Vertical 0 degree				Cranial +30 degrees				Caudal -30 degrees			
		No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)
Angle around (degree)	0	7.95	1.58	80.11%	14.03dB	7.86	1.67	78.74%	13.45dB	8.84	2.03	77.03%	12.78dB
	45	7.48	1.58	78.91%	13.52dB	7.30	1.65	77.34%	12.89dB	8.68	2.01	76.87%	12.72dB
	90	6.99	1.51	78.47%	13.34dB	6.99	1.61	76.93%	12.74dB	8.52	2.00	76.56%	12.6dB
	135	6.87	1.44	79.06%	13.58dB	6.73	1.56	76.87%	12.72dB	8.36	1.88	77.50%	12.95dB
	180	7.27	1.36	81.28%	14.55dB	6.94	1.49	78.47%	13.34dB	7.69	1.73	77.47%	12.94dB
	225	7.29	1.35	81.51%	14.66dB	6.80	1.43	78.89%	13.51dB	8.03	1.74	78.31%	13.28dB
	270	7.53	1.29	82.88%	15.33dB	7.51	1.42	81.04%	14.44dB	9.39	1.64	82.54%	15.16dB
	315	7.51	1.47	80.48%	14.19dB	7.50	1.58	78.91%	13.52dB	9.21	1.93	79.05%	13.58dB
Ave.		7.36	1.45	80.34%	14.15dB	7.20	1.55	78.40%	13.33dB	8.59	1.87	78.17%	13.25dB

Electromagnetic wave attenuation effect judgment test results (128MHz/64MHz) in surface of the body phantom

- **128MHz = 77.22%(ave.)**

Surface of the body phantom													
	Vertical 0 degree				Cranial +30 degrees				Caudal -30 degrees				
	Non Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	Non Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	Non Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	
Angle around (degree) 0	131.53	28.11	78.63%	13.4dB	90.88	26.83	70.47%	10.6dB	167.69	27.21	83.77%	15.79dB	
45	136.26	28.07	79.40%	13.72dB	97.47	26.83	72.48%	11.21dB	170.25	27.55	83.82%	15.82dB	
90	136.90	27.45	79.95%	13.96dB	124.82	26.49	78.77%	13.46dB	164.60	29.43	82.12%	14.95dB	
135	136.87	30.36	77.82%	13.08dB	143.40	28.36	80.22%	14.08dB	123.10	32.27	73.78%	11.63dB	
180	132.10	31.86	75.88%	12.35dB	149.40	29.48	80.27%	14.1dB	105.09	34.27	67.39%	9.73dB	
225	133.43	31.80	76.17%	12.46dB	148.65	29.49	80.16%	14.05dB	112.90	33.94	69.93%	10.44dB	
270	134.17	30.27	77.44%	12.93dB	136.41	28.67	78.98%	13.55dB	128.63	31.49	75.52%	12.22dB	
315	130.81	30.02	77.05%	12.78dB	100.83	27.62	72.61%	11.25dB	149.45	28.91	80.65%	14.27dB	
Ave.	134.01	29.74	77.79%	13.09dB	123.98	27.97	76.75%	12.79dB	140.22	30.64	77.12%	13.11dB	

- **64MHz = 86.14%(ave.)**

Surface of the body phantom													
	Vertical 0 degree				Cranial +30 degrees				Caudal -30 degrees				
	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	No Wearing (V/m)	Wearing (V/m)	Attenuation rate (%)	Logarithm (dB)	
Angle around (degree) 0	67.11	8.13	87.89%	18.33dB	58.39	8.52	85.41%	16.72dB	68.34	6.40	90.63%	20.56dB	
45	59.28	8.13	86.29%	17.26dB	59.84	8.54	85.73%	16.91dB	67.73	6.45	90.48%	20.43dB	
90	59.26	8.06	86.39%	17.32dB	55.93	8.45	84.89%	16.41dB	52.81	6.47	87.74%	18.23dB	
135	46.49	7.81	83.19%	15.49dB	49.81	8.02	83.90%	15.86dB	52.80	6.55	87.59%	18.12dB	
180	46.05	7.56	83.59%	15.70dB	50.74	7.76	84.70%	16.31dB	47.10	6.56	86.08%	17.13dB	
225	46.56	7.43	84.04%	15.94dB	50.69	7.46	85.29%	16.65dB	45.39	6.57	85.53%	16.79dB	
270	51.20	7.50	85.34%	16.68dB	48.20	7.55	84.34%	16.10dB	49.73	6.31	87.32%	17.94dB	
315	61.21	7.78	87.29%	17.92dB	51.02	8.05	84.22%	16.04dB	59.73	6.25	89.54%	19.61dB	
Ave.	54.65	7.80	85.50%	16.83dB	53.08	8.04	84.81%	16.38dB	55.45	6.44	88.11%	18.60dB	

Summary of Results

1. RF wave attenuation curve (sensitivity distribution)

◆RF attenuation effect became stronger in the order of Control <Silver2 <Silver4.

⇒ There is no statistically significant difference. (N.s.)

Summary of Results

2. SNR

- ✓ Silver 2 : 97.35%　Silver 4 : 97.52%
- ✓ **In SNR comparison, overall result was 97.44% (avg.).**

◆**Comparison of the number of use of protective clothing**

① **Use of protective clothing**

⇒ Statistically significant difference (P<0.01)

②**Use of one or two of protective clothing**

⇒ **MEAN ; Silver 4 SNR < Silver2SNR**

⇒ No statistically significant difference. (N.s.)

◆**Comparison of 1.5T or 3.0T (resonance frequency)**

⇒ No statistically significant difference. (N.s.)

◆**Comparison of cross-sectional images (Sag or Cor)**

⇒ No statistically significant difference. (N.s.)

Summary of Results

3. The correlation between the electromagnetic wave attenuation effect judgment test

◆ **Use of one protective clothing (Silver2)**

①Inside of the human body phantom

⇒ The attenuation effect was **78.80%.**

⇒ No statistically significant difference. (N.s.)

②Surface of the human body phantom

⇒ The attenuation effect was **82.56%.**

⇒ No statistically significant difference. (N.s.)

◆ **Comparison of directional dependency**

⇒ No statistically significant difference. (N.s.)

Conclusion

It is possible for capsule endoscope protective clothing to shield the signal other than head area.

We will be able to provide safe MRI examination by removing the risk of heat generation of body metal and heart devices.

カプセル内視鏡用防護服は、頭部以外の信号を遮蔽することが可能である。

心臓デバイスや体内の金属の発熱リスクを無くし、安全なMRI検査を提供することが可能である。

Conclusion

Capsule endoscope protective clothing will reduce not only various risks to MRI staffs, but also mental and physical stress of patients.

We believe that it is possible to protect pacemakers and ICD from the electromagnetic wave by continuing the improvement.

カプセル内視鏡用防護服は、MRIのスタッフの様々なリスクの低減につながり、また、患者の身体的ストレスの負担や精神的ストレスを減少させるのに有用である。

我々は、改良を継続することで電磁波からペースメーカーやICDを保護することができると信じています。

“Thank you for your attention.”