Article title：Comparison of the 3D-IR = BTFE method and the conventional method in the head MRI contrast

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Abstract

Contrast MRI examination using gadolinium contrast agent is necessary for diagnosis. NSF was reported as a serious side effect by gadolinium contrast agent in 2007. Furthermore, it was found that gadolinium contrast agent was deposited in the dentate nucleus and vitiligo in 2013. These hazards have increased the need for proper use of gadolinium contrast media. In this study, an imaging method with high contrast and high signal-to-noise ratio was created and investigated. Compared with the conventional imaging method, it is shown that it is high contrast, suggesting the possibility of weight loss of the contrast medium.

Introduction

Metastasis in the head region The first selection examination for retrieval purpose is the contrast MRI examination, the diagnosis of metastatic brain tumor is important for the stage judgment, and the contrast examination using the gadolinium contrast agent is performed as a routine for the purpose of metastatic retrieval. In addition, since the detection rate is improved by the double dose administration of gadolinium contrast agent, examination by double dose administration of gadolinium contrast agent is also conducted.

MRI examination using a contrast agent also plays an important role in differential diagnosis in other brain tumor examination.

However, since renal systemic fibrosis (Nephrogenic Systemic Fibrosis (hereinafter referred to as "NSF"), which is a serious side effect of the contrast agent, has been reported, it is confirmed that the renal function is confirmed for the use of the contrast agent, And the amount of contrast medium used and the interval of use have been further optimized.

According to the report of Kanda et al. In 2013, the risk of deposition on the dentate nucleus and vitiligo of the brain becomes clear in the contrast medium which is not a macrocyclic structure, and the contrast agent other than the macrocyclic structure is now less used There. Subsequent investigations reveal that even a macrocyclic structure is slightly deposited in the brain, and it is necessary to properly use gadolinium contrast agent to avoid unnecessary risk.

As imaging methods after the use of gadolinium contrast agent, 3 to 6 mm slice thickness of T1 weighted image of Spin echo method and 3 dimensional T1 weighted image of 3D gradient echo method (hereinafter referred to as 3D-GRE) etc. are widely used as routine images There. In the 3T device, the MPRAGE method is often used due to the influence of SAR and T1 extension. The RFA variable imaging method which

changes the angle of the reversal pulse which lowers the blood flow signal also has the possibility of clearly depicting the contrast region, so it is being used in the mounting apparatus.

Purpose

If there is an imaging method which can emphasize the contrast effect, body weight and danger can be reduced by weight loss of the contrast agent, and the possibility of improving the detection rate against the background of the contrast rise also increases.

Therefore, based on Balanced Turbo Field Echo (BTFE) method which is a Coherent type Gradient echo method which is a Sequence of a high signal-to-noise ratio, in order to obtain higher T1 emphasis from the BTFE method which is the contrast of T2 * / T1, an Inversion Recovery (Hereinafter referred to as "IR" method) was added to 3D-GRE using 3D BTFE (hereinafter referred to as 3D-IR-BTFE) method.

Materials & Methods

Eight cases of contrasting examination for target metastatic brain tumor search.

The equipment used is a superconducting 1.5 Tesla MRI machine (Intera Achieva Nova, manufactured by PHILIPS).

The coil used is 8CH SENSE Head coil.

As a contrast medium to be used, double dosage of gadolinium (HP-DO 3 A) (0.4 ml / kg) was administered.

EZR was used for statistical processing.

A slice thickness of 3 mm of the T1 weighted image of the two-dimensional Spin echo method of ordinary routine examination and a slice thickness of 1 mm of the three dimensional Gradient echo method were imaged and a slice thickness of 1 mm of 3D-IR-BTFE was imaged. If the imaging start of each sequence is the same after gadolinium imaging, there is a possibility that the difference in contrast effect may be reflected in the contrast, so the order of imaging is changed at random every time. After gadolinium imaging, imaging was started after 5 minutes, taking into account the distribution to the brain.

The main imaging conditions of each are shown in Table1 and Table2.

FOV	230	Slice thickness	3mm
RFOV	80	Slice gap	0mm
MATRIX	256	Scan mode	MS
RECON	512	Technique	SE
Scan%	70	TR	462
SENSE	No	TE	15
Slices	48	Flip angle	90
NSA	2	Scan time	6min49sec

Table 1: Major parameters of CE T1WI 3mm

FOV	230	Slice thickness	1mm
RFOV	80	Slice gap	0mm
MATRIX	224	Scan mode	3D(IR delay:1200)
RECON	256	Technique	FFE(TFE factor:256)
Scan%	110	TR	4.3
SENSE	YES (P:2.5,S:1.0)	TE	2.2
Slices	140	Flip angle	60
NSA	2	Scan time	3min38sec

Table 2: Major parameters of IR 3D BTFE 1mm

For the sequence of 1 mm original image, it was created using MPR so that it can be compared with 3 mm thick image used in the Spin echo method and used for evaluation.

Evaluation method was compared with visual evaluation with contrast.

Visual evaluation was conducted by three medical radiological technicians, and the number of lesions was counted and evaluated. The years of experience of the radiological technologists evaluated were 13 years, 10 years, and 3 years, respectively.

In the contrast comparison, the region of interest (ROI) was set for lesion and brain parenchyma and compared and evaluated.

Results

A part of the image actually obtained is shown in Figure1. An example of ROI setting is shown in Figure2.

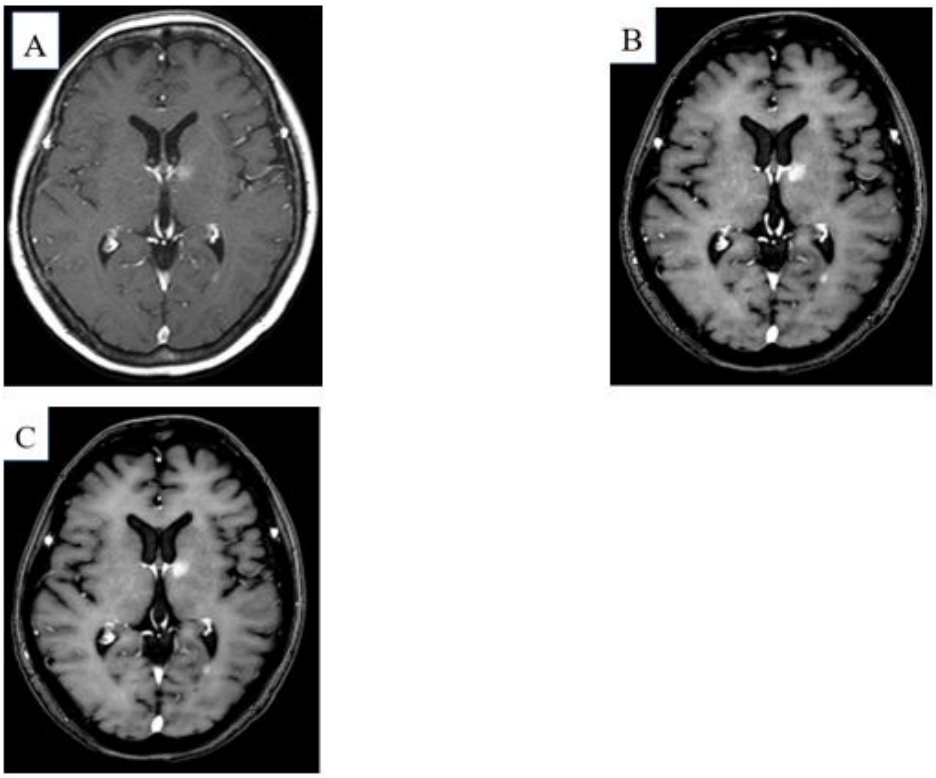


Figure 1: Image example A: Post CE SE T1WI 3mm, B: Post CE 3D-IR-BTFE 1mm, C: Post CE 3D-IR-BTFE MPR 3mm

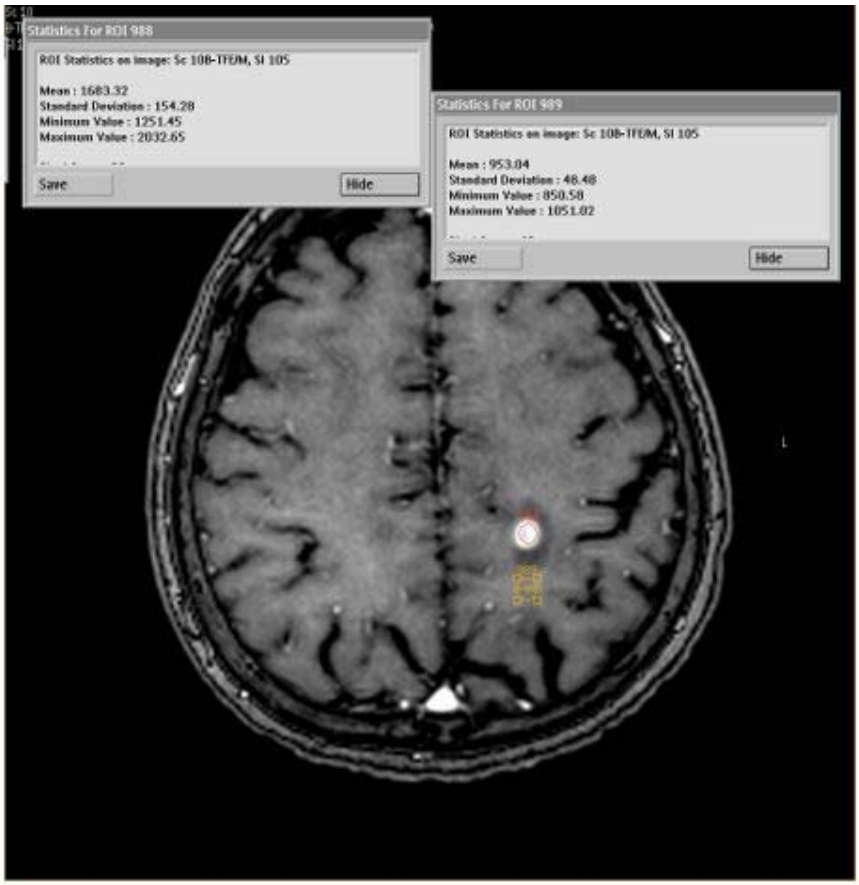


Figure 2: The setting of the contrast region of interest is shown

The contrast results are shown in Table 3. Table 4, Table 5, Table 6 show the number of lesion counts by evaluator, respectively.

	3mm SE			IR-BTFE 3mm MPR			IR-BTFE 1mm		
No	**Leision**	**White matter**	**contrast**	**Leision**	**White matter**	**contrast**	**Leision**	**White matter**	**contrast**
1	**767.59**	**504.1**	**263.49**	**1194.65**	**732.48**	**462.17**	**1241.48**	**706.61**	**534.87**
2	**818.6**	**547.67**	**270.93**	**1274.98**	**835.44**	**439.54**	**1394.85**	**839.19**	**555.66**
3	**802.47**	**502.89**	**299.58**	**1159.52**	**679.9**	**479.62**	**1210.07**	**691.3**	**518.77**
4	**1017**	**520.36**	**496.64**	**1498.92**	**957.27**	**541.65**	**1683.32**	**953.04**	**730.28**

5	**844.94**	**516.37**	**328.57**	**1365.81**	**977.68**	**388.13**	**1635.77**	**985.81**	**649.96**
6	**735.72**	**516.37**	**219.35**	**1291.14**	**977.68**	**313.46**	**1514.3**	**985.81**	**528.49**
7	**726.35**	**486.47**	**239.88**	**1318.84**	**946.68**	**372.16**	**1339.56**	**899.97**	**439.59**
8	**801.8**	**480.65**	**321.15**	**1216.07**	**774.04**	**442.03**	**1213.19**	**761.98**	**451.21**
9	**811.22**	**531.24**	**279.98**	**1082.89**	**750.08**	**332.81**	**1189.34**	**688.42**	**500.92**
10	**809.4**	**521.76**	**287.64**	**1227.62**	**795.68**	**431.94**	**1202.55**	**797.5**	**405.05**
11	**666.41**	**521.76**	**144.65**	**1034.51**	**795.68**	**238.83**	**1068.88**	**797.5**	**271.38**
12	**687.53**	**549.74**	**137.79**	**1006.08**	**776.77**	**229.31**	**1149.89**	**796.15**	**353.74**
13	**797.74**	**569.01**	**228.73**	**1189.14**	**870.76**	**318.38**	**1269.73**	**862.68**	**407.05**
14	**565.29**	**538.04**	**27.25**	**903.09**	**835.41**	**67.68**	**940.13**	**847.72**	**92.41**
15	**801.79**	**493.68**	**308.11**	**1064.89**	**784.71**	**280.18**	**1187.61**	**752.45**	**435.16**
16	**774.31**	**493.68**	**280.63**	**1189.78**	**784.71**	**405.07**	**1217.95**	**752.45**	**465.5**
17	**849.28**	**485.54**	**363.74**	**1296.03**	**809.89**	**486.14**	**1557.66**	**779.61**	**778.05**
18	**946.97**	**476.38**	**470.59**	**1339.57**	**781.06**	**558.51**	**1415.77**	**791.63**	**624.14**
19	**912.22**	**560.43**	**351.79**	**1434.4**	**878.8**	**555.6**	**1506.11**	**897.93**	**608.18**
20	**711.89**	**473.89**	**238**	**1154.17**	**736.36**	**417.81**	**1291.93**	**674.3**	**617.63**
Average	**792.426**	**514.5**	**277.926**	**1212.11**	**824.05**	**388.06**	**1311.5**	**813.1**	**498.4**

Table 3: Contrast results(SE vs IR-3D-BTFE)

ROI	T1W SE 3mm	IR-3D-BTFE 1mm	MPR 3mm
1	4	4	4
2	8	9	7
3	13	16	11
4	6	7	6
5	0	0	0
6	0	0	0
7	2	3	3
8	0	0	0
9	9	11	10
10	41	44	38
11	0	0	0
Sum	83	94	79

Table 4: evaluator 1

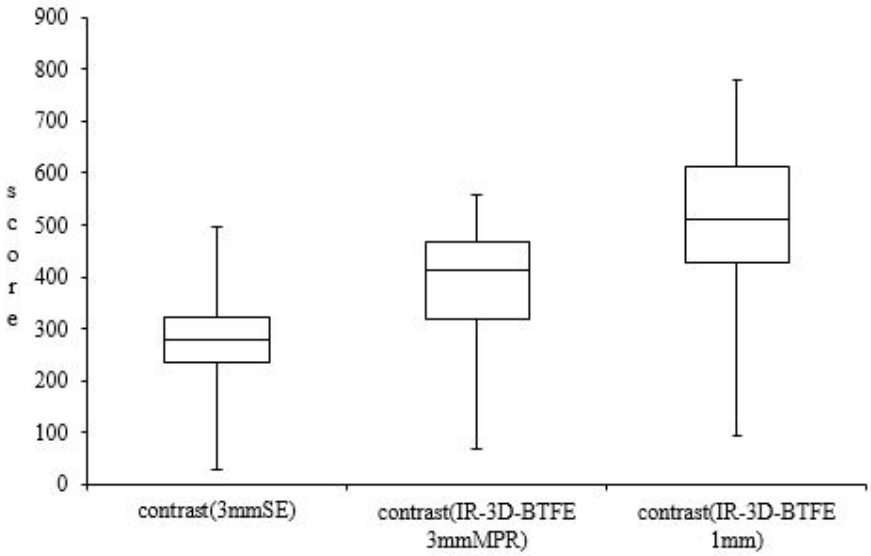
ROI	T1W SE 3mm	IR-3DBTFE 1mm	MPR 3mm
1	3	4	3
2	6	9	6
3	8	15	15
4	4	6	6
5	0	0	0
6	0	0	0
7	3	5	4
8	0	0	0
9	6	9	9
10	29	37	33
11	1	0	1
Sum	60	85	77

Table 5: evaluator 2

ROI	T1W SE 3mm	IR-3D-BTFE 1mm	MPR 3mm
1	3	5	3
2	5	9	7
3	15	17	15
4	4	7	6
5	0	0	0
6	0	0	0
7	3	4	4
8	0	0	0
9	11	12	12
10	39	41	37
11	0	0	0
Sum	80	95	84

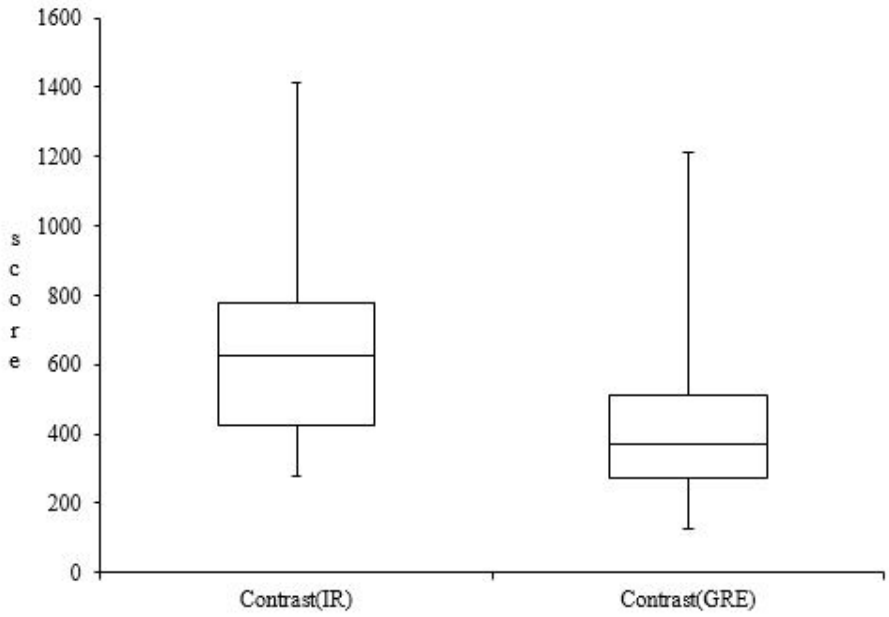
Table 6: evaluator 3

Graph 1 shows a box plot of the 2D-SE contrast and the IR-3D-BTFE contrast.



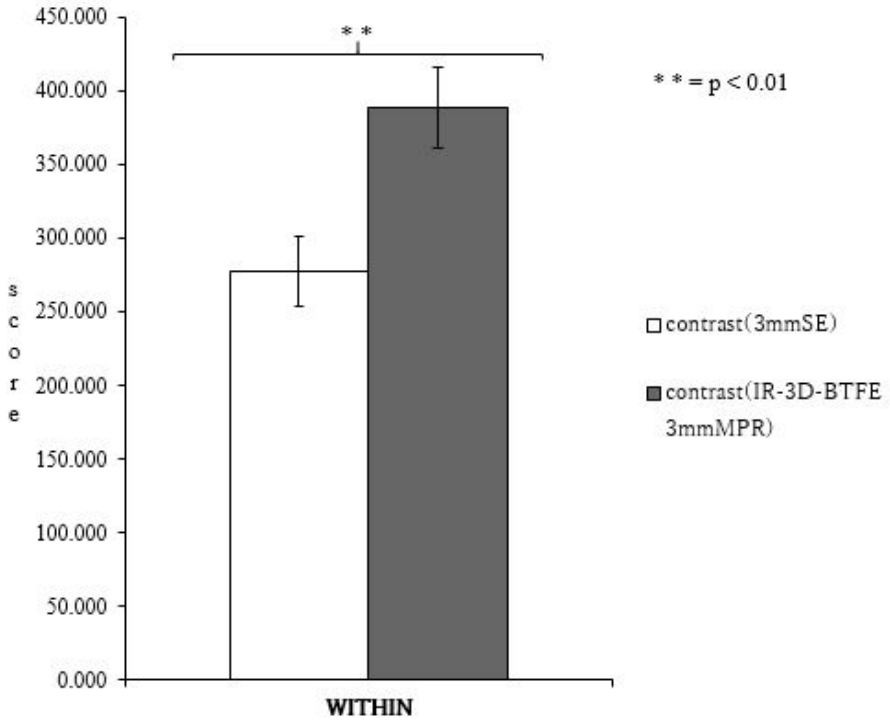
Graph 1: Boxplot, SE contrast vs BTFE contrast

Graph 2 shows a box plot of Contrast of IR-3D-BTFE and Contrast of 3D-GRE.



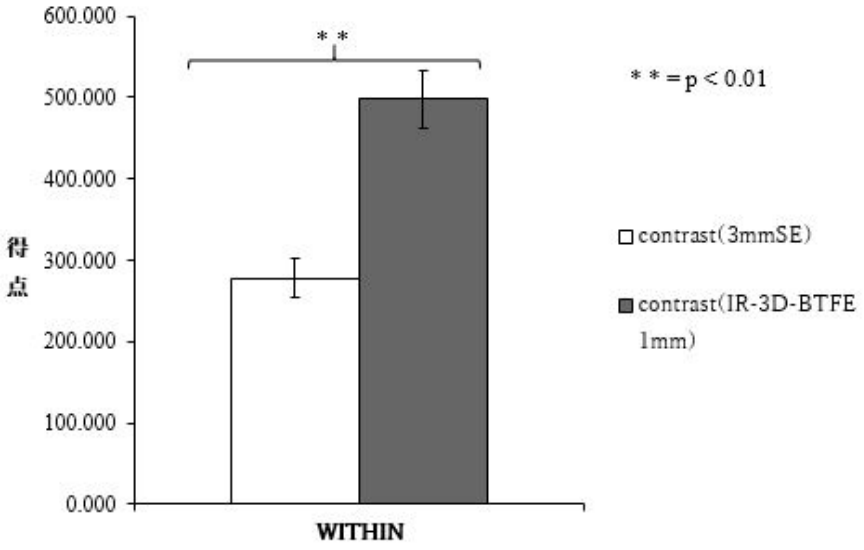
Graph 2: Boxplot, BTFE contrast vs GRE contrast

The results of the test of the difference between the corresponding mean values in the ROI in 2D-SE and IR-3D-BTFE are shown in Graph 3. The difference test was $t(19) = -8.252$, $p < .01$ ($p = 0.0000001$), $d = -9.64$.



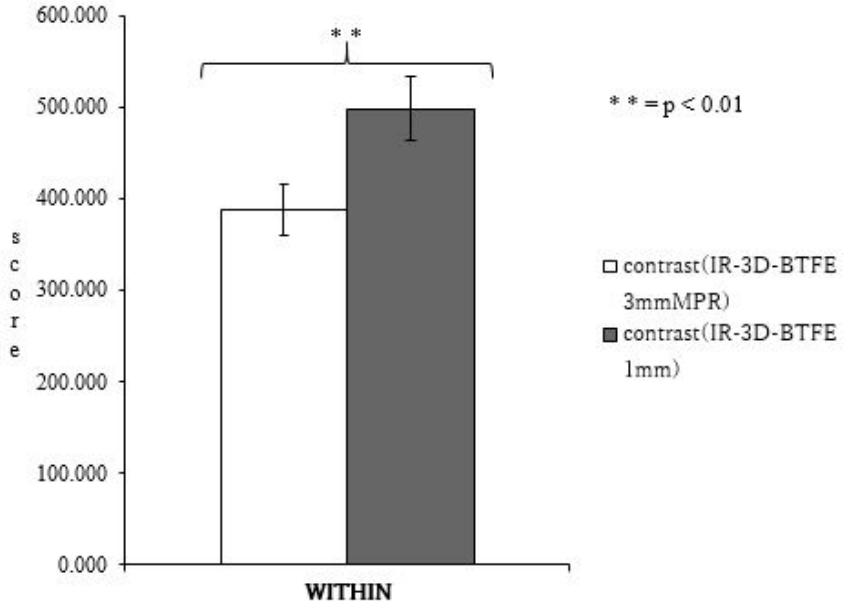
Graph 3: Test of difference of corresponding mean value SE contrast vs BTFE 3mm contrast

The results of the test of the difference between the corresponding mean values in the ROI at 2 D-SE and IR-3D-BTFE 1 mm are shown in Graph 4. The difference test was t (19) = - 10.828, p <.01 (p = 0.0000000014), d = -1.656.



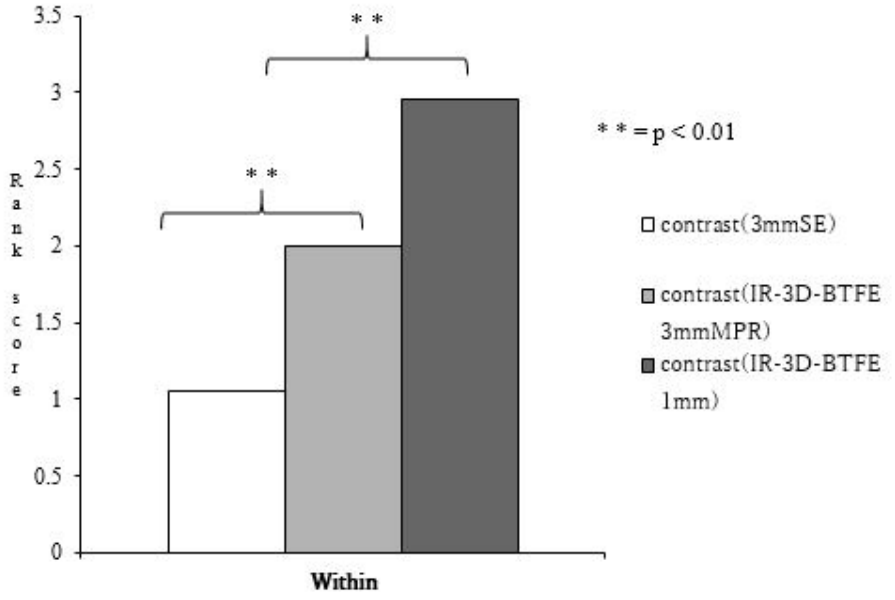
Graph 4: Test of difference of corresponding mean value SE contrast vs BTFE 1mm contrast

The result of the test of the difference between the corresponding average values in the ROI at IR-3D-BTFE 3 mm and IR-3D-BTFE 1 mm is shown in Graph 5. The difference test was t (19) = -5.637, p <.01 (p = 0.000019), d = -787.



Graph 5: Test of difference of corresponding mean value BTFE 3mm contrast vs BTFE 1mm contrast

Graph 6 shows the results of the test (Friedman test) of the difference in corresponding average rankings between 2D-SE and IR-3D-BTFE 3 mm and IR-3D-BTFE 1 mm. The difference test was z (14) = 36.100, p <.01 (p = 0.00000001), r = .602.

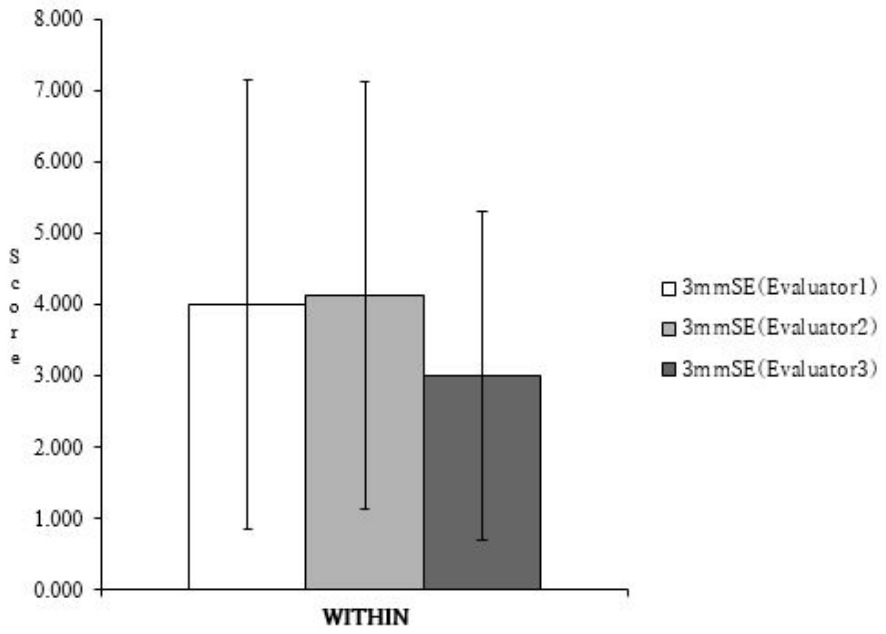


Graph 6: Nonpara_r, SE 3mm contrast vs BTFE 3mm contrast vs BTFE 1mm contrast

The result of 3 mm SE for the test of the difference of the corresponding mean value in the evaluator is shown in Graph 7. The difference test at 3 mm SE (Evaluator 1) - 3 mm SE (Evaluator 2) was t (7) = - 0.552, p = 0.598, d = - 0.014.

The difference test at 3 mm SE (Evaluator 1) - 3 mm SE (Evaluator 3) was t (7) = 1.155, p = 0.286, d = 0.121.

The difference test for 3 mm SE (Evaluator 2) - 3 mm SE (Evaluator 3) was t (7) = 1.567, p = 0.161, d = 0.141.



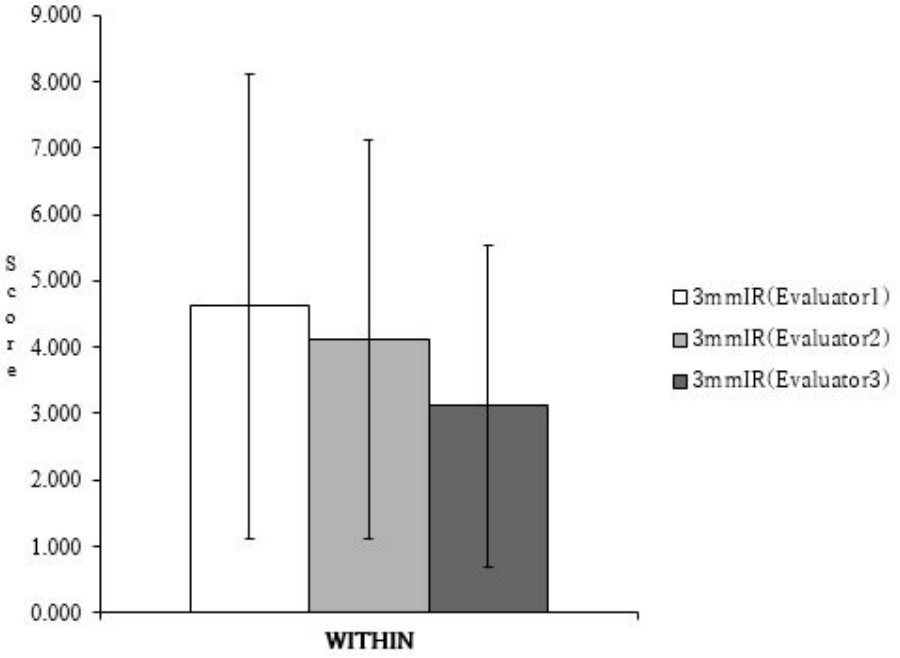
Graph 7: Test of difference of corresponding mean value Evaluator(SE)

Graph 8 shows the result of 3 mm IR-3D-BTFE, which is a test of the difference between corresponding mean values in the evaluator.

The difference test at 3 mm IR (Evaluator 1) - 3 mm IR (Evaluator 2) was t (7) = 0.882, p = 0.407, d = 0.051.

The difference test at 3 mm IR (Evaluator 1) - 3 mm IR (Evaluator 3) was t (7) = 1.361, p = 0.215, d = 0.166.

The difference test at 3 mm IR (Evaluator 2) - 3 mm IR (Evaluator 3) was t (7) = 1.595, p = 0.154, d = 0.122.



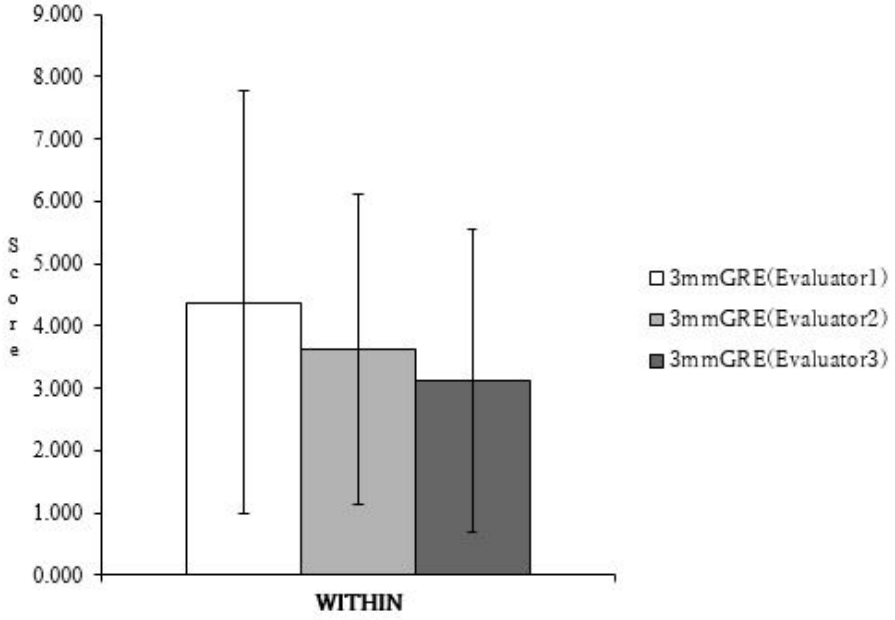
Graph 8: Test of difference of corresponding mean value Evaluator(BTFE 3mm)

Graph 9 shows the results of 3 mm 3D-GRE for the test of the differences of corresponding mean values in the evaluator.

The difference test at 3 mm GRE (Evaluator 1) - 3 mm GRE (Evaluator 2) was t (7) = 0.814, p = 0.442, d = 0.084.

The difference test at 3 mm GRE (Evaluator 1) - 3 mm GRE (Evaluator 3) was t (7) = 1.279, p = 0.241, d = 0.142.

The difference test at 3 mm GRE (Evaluator 2) - 3 mm GRE (Evaluator 3) was t (7) = 1.871, p = 0.103, d = 0.067.



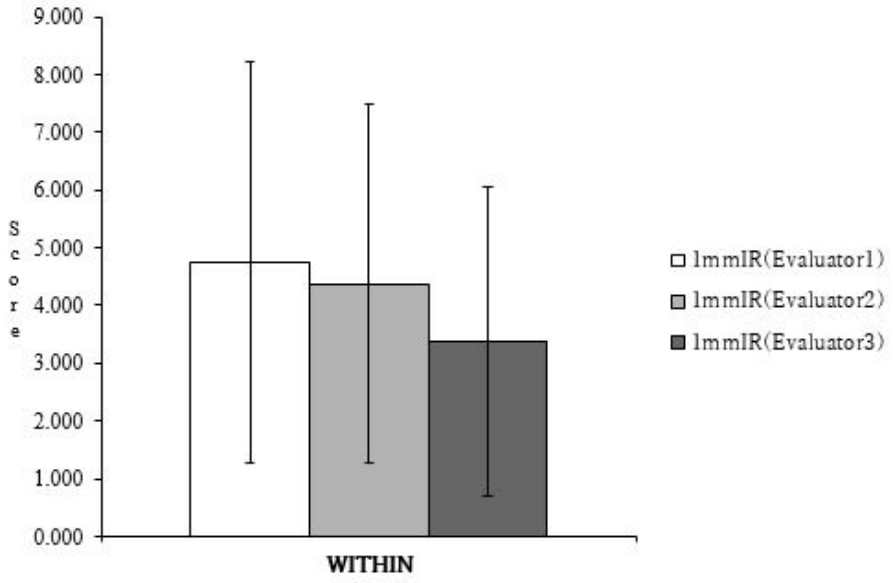
Graph 9: Test of difference of corresponding mean value Evaluator(GRE 3mm)

Graph 10 shows the result of 1 mm IR-3D-BTFE for the test of the difference of corresponding mean values in the evaluator.

The difference test at 1 mm IR (Evaluator 1) - 1 mm IR (Evaluator 2) was t (7) = 0.893, p = 0.401, d = 0.038.

The difference test at 1 mm IR (Evaluator 1) - 1 mm IR (Evaluator 3) was t (7) = 1.629, p = 0.147, d = 0.148.

The difference test at 1 mm IR (Evaluator 2) - 1 mm IR (Evaluator 3) was t (7) = 2.000, p = 0.085, d = 0.115.



Graph 10: Test of difference of corresponding mean value Evaluator(BTFE 1mm)

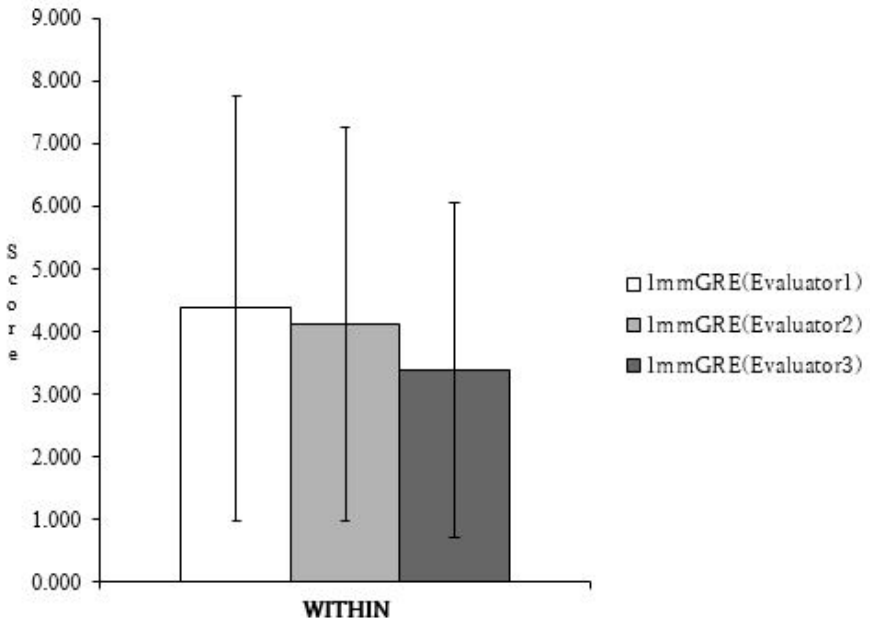
Graph 11 shows the result of 1 mm 3D-GRE for the test of the differences of corresponding mean values in the evaluator.

The difference test at 1 mm GRE (Evaluator 1) - 1 mm GRE (Evaluator 2) was t (7) = 1.000, p = 0.351, d = 0.026.

The difference test at 1 mm GRE (Evaluator 1) - 1 mm GRE (Evaluator 3) was t (7) = 1.366, p = 0.214, d = 0.110.

The difference test at 1 mm GRE (Evaluator 2) - 1 mm GRE (Evaluator 3) was t (7) = 1.528, p = 0.170, d = 0.086.

By evaluator, there was no significant difference in sequence or experience years.

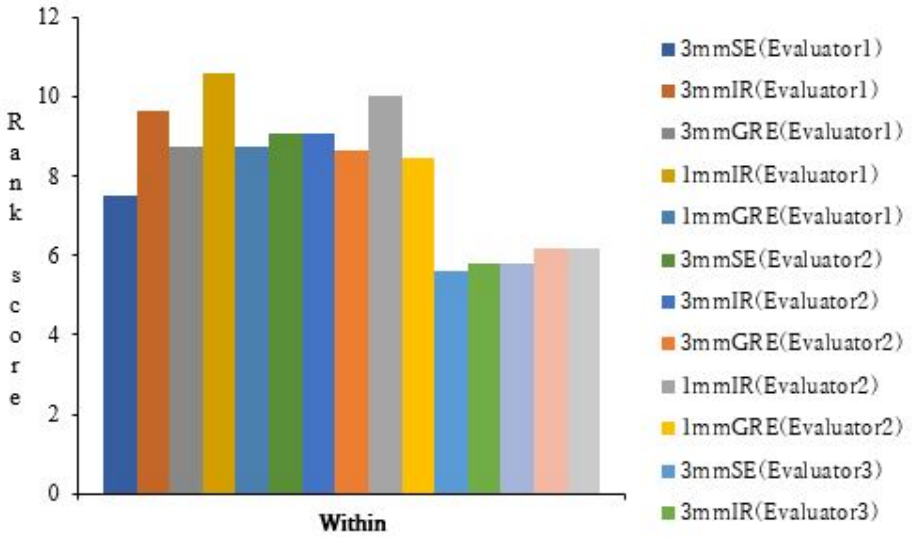


Graph 11: Test of difference of corresponding mean value Evaluator(GRE 1mm)

Graph 12 shows the result of the test of the difference in average rank corresponding to the visual evaluation (Friedman test).

The difference test was z (14) = 29.882, p <.01 (p = 0.007), r = 0.249.

Based on the results of ROI, excellent results were obtained with significant difference in IR-3D-BTFE. Based on visual evaluation results, 1 mm IR-3D-BTFE was the best result for the two evaluators.



Graph 12: Nonpara_r, Evaluator

Discussion

From the results, 3D-IR-BTFE was excellent for all items.

Although BTFE which is a steady state sequence is originally superior to T2 emphasis, in Sequence Design designed this time, we added IR to strengthen longitudinal magnetization and that in SSFP series sequence we do not acquire transition period By extending the Shot interval which is the parameter of the interval between imaging and imaging to acquire the signal and completely restoring the longitudinal magnetization, it contributes to longitudinal relaxation and excellent T1 emphasis can be obtained I thought about the possibility.

Moreover, since BTFE is a Sequence superior in SNR because it utilizes all signals in the image, it is thought that SNR can be secured even in a short time of imaging time compared with the Gradient echo method, and good results were obtained It was.

Difference in count was observed by the evaluator at the visual evaluation lesion count, but this was considered to be the difference in the evaluation of the high-signal part of a small size that is lost from a lesion or blood vessel. Before doing statistical processing, I also considered the difference in the count by the years of experience, but there was no significant difference from the result by the years of experience.

In this issue, considering longitudinal relaxation, Sequence Design examined the shot

interval as 4000 ms, but I thought that investigating IR and Shot interval values is necessary in order to obtain further contrast in the future.

Conclusions

This research is the title presented at the 37 th Annual Meeting of the Japanese Society of Magnetic Resonance Medicine in September 2009. As described in the background, since the use of gadolinium contrast agent has become more rigorous, we decided to go back to the thesis.

The present study found that the 3D-IR-BTFE method with IR added has excellent contrast.

It is possible to acquire images of thin slices in a shorter time than conventional imaging methods, and as a new standard for devices capable of the Coherent type Gradient echo method, if the contrast is set to the same level as the Gradient echo method, the contrast agent can be reduced The possibility was also suggested.

It was also suggested that 3D-IR-BTFE, which is excellent in contrast contrast, may be useful for whole body examination if the site is less affected by motion.

We will further advance this research and expect that examination of appropriate contrast agent reduction based on high contrast will be conducted.

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