

1

2

: MRI (AVM) MR 가 ,  
: AVM MRI (nidus) ,  
6 ( ; 6-46 ) 25 (39 )  
. MRI T1, T2 .  
7 MRI .  
: AVM 6 46 25 16 1  
18 5 (25%) , 11 1  
16 12 , 2  
, 2 9  
16 -  
가  
T1 , T2 25  
21 , 4 . 7 6 MRI AVM  
9 . , 1 MRI 가  
:  
AVM 가 -  
가 가 .

(AVM) 가 AVM  
(1). AVM MRI AVM  
(embolization) 가 MRI AVM MR  
가 가 AVM MR  
(MRI), CT 가 AVM  
AVM (2,3) CT  
MRI AVM  
AVM MRI AVM 4  
80 ( ; 6-46 )가 25 MRI  
15 , 10  
25.6 . 12 , 6 ,  
5 , 2 .

1.5T MR (Thosiba MRT/200FX-II, Nasu, Japan/ Siemens Magnetom Vision, Germany)

(Leksell Gamma-knife Type B23004, Eleckta, Stockholm, Sweden)

(marginal dose) 18-30 Gy( 23.1 Gy)

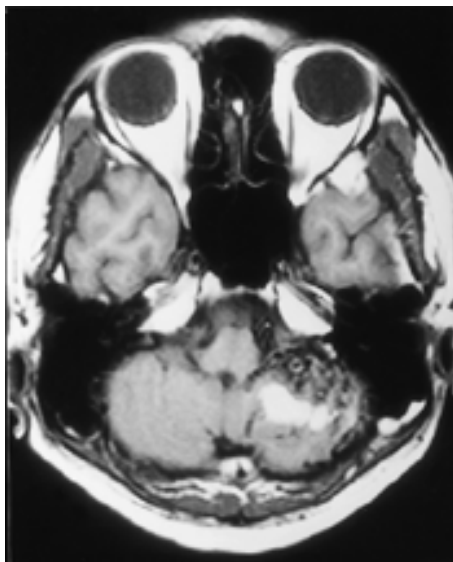
T1(TR/TE 550-600/12-20) T2 (TR/TE 2200/80 3000-3800/90)

(signal void lesion ; nidus)

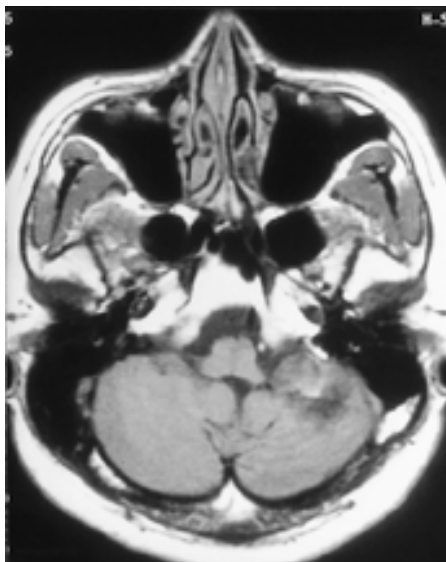
25 1 1

T1 T2  
가

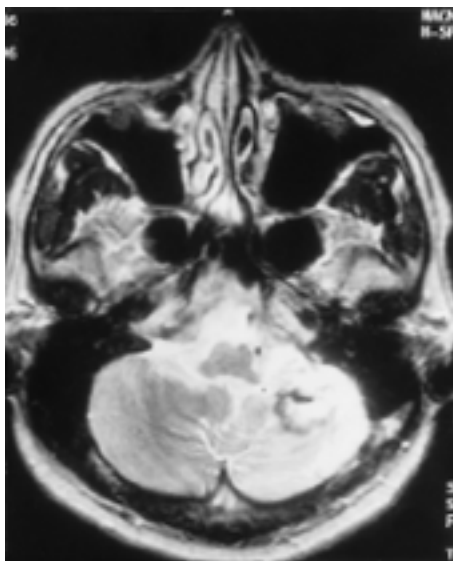
1 cm<sup>3</sup> 7 , 1-4cm<sup>3</sup>  
8 , 4-10cm<sup>3</sup> 7 , 10cm<sup>3</sup> 3  
25 6 1 가  
18 18 , 1 2 11 12 , 2  
7 8 가  
50% , 50% ,  
PA(1 mmol/kg) T1  
Gd-DT-



A



B



C



D

Fig. 1. Left cerebellar hemispheric AVM(A) was obliterated on follow-up MR images obtained in 46 months(B-D) after gamma-knife radiosurgery. Obliterated nidus of AVM shows slight low signal intensity on T1 weighted images(B) and high signal intensity on T2 weighted images(C). After Gd-DTPA enhancement, nodular enhancement(arrow) is seen in previous AVM site(D).

T1 T2 (nidus) 50% 가 3 1 2  
가 1 2  
7 MRI AVM 가 2 (Fig.1) 15 13  
가 AVM  
MRI 16 4cm<sup>3</sup> 11  
16.7 4cm<sup>3</sup> 5 25.2  
6 1 가 18  
25 가 1 18 5  
(25%) 1 15 13 (86.7%)  
(nidus) 4-10 cm<sup>3</sup> 1  
가 1 4 1 T1, T2  
(Table 1). 1 2  
가 12 가 1, - 2,  
7, 1, 1 T1, T2  
- 가 T1, T2  
11 12 9 9 (75%)가 , 2 3  
(25%)가 50% 2 가  
7 8 5 5 (62.5%)가 , 3  
가 50%

Table 1. Summary of Follow-up MRI after Gamma Knife Radiosurgery for Brain AVM

Case	Age/Sex	Follow-up MRI (Months)	Volume Reduction Rate(% , Months)
1	17/F	13	Total
2	23/M	12	Total
3	30/M	7, 13	Total(7)
4	24/F	8	Total
5	14/M	8	Total
6	36/F	7, 23	Total(23)
7	27/M	6, 46	Total(46)
8	7/M	6, 20	Total(20)
9	22/M	19	Total
10	27/F	13, 31	Total(13)
11	22/F	6, 17	Total(17)
12	21/F	28	Total
13	51/F	24	Total
14	10/F	43	Total
15	44/M	7, 18	Total(18)
16	20/M	7, 14	Total(7)
17	45/M	8	64.8
18	15/M	6	55.8
19	31/M	6	19.3
20	32/M	10	91.7
21	65/M	8	79.9
22	8/M	11	89.9
23	31/M	6	84.8
24	19/F	7, 13, 22, 31	89.2(31)
25	24/F	7, 19, 27, 32	96.8(32)

sis),  
(4).

(AVM)

AVM  
1 (Fig. 3)

AVM

MRI

6  
MRI

MRI  
3

6

11),

가  
MRI

40%, 2  
1

75-85%

AVM

81.3%

(8,13-16).

AVM

1

(5-  
(12).  
30-

(11,17).

AVM

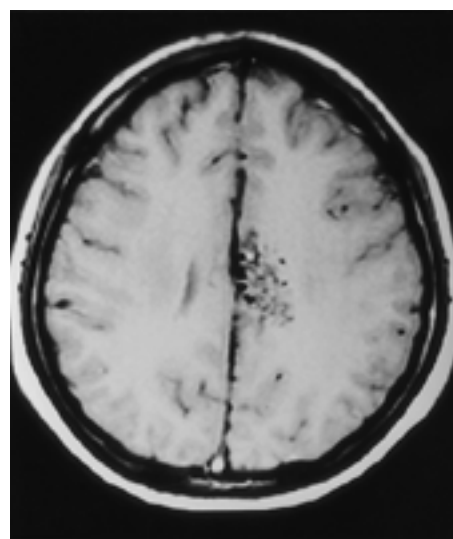
가 (18,19).

(glio-

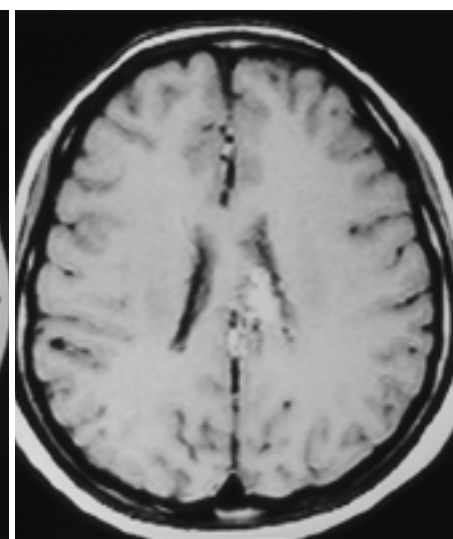
가

가

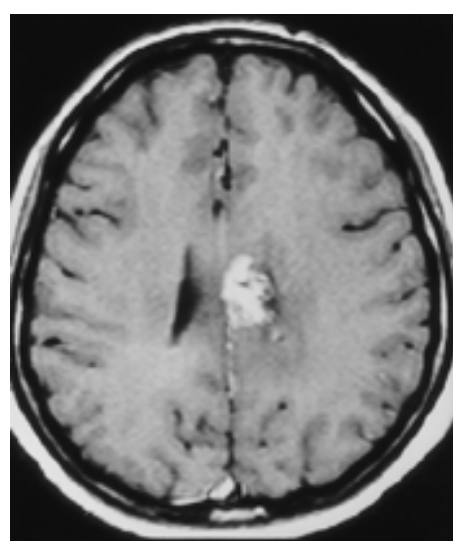
가



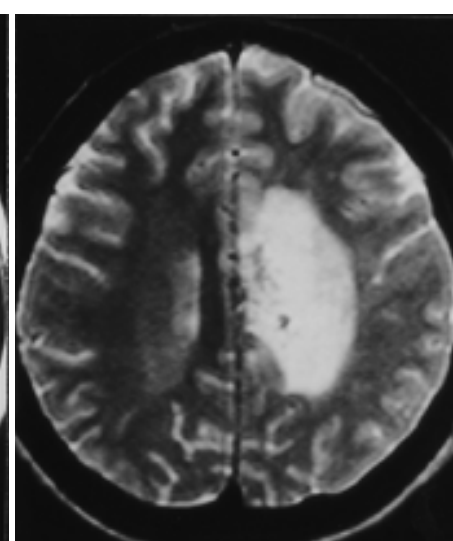
A



B



C



D

Fig. 2. Changes of enhancing patterns at the nidus of brain AVM. The enhancing pattern of left callosal AVM(A) on MR images was changed in 16 months(B) and 25 months(C) after gamma-knife radiosurgery. Nodular enhancing portions had been increased and only nodular enhancing portion was remained in 25 months after radiosurgery. T2 weighted images(D) obtained in 25 months after radiosurgery shows diffuse high signal intensity near the obliterated nidus of AVM.

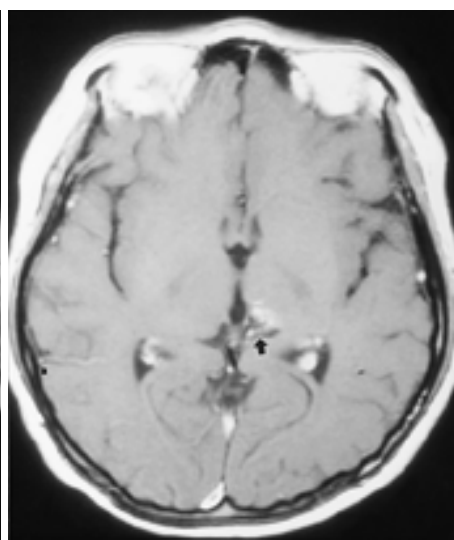
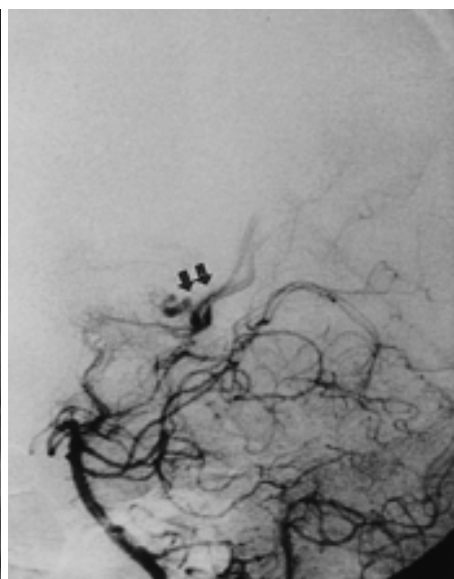


Fig. 3. Thalamic AVM(A) was changed to decreased signal void lesion and increased nodular enhancing portion in follow-up MR images of 27 months after radiosurgery(B). But linear signal void lesion (arrow) was remained. Initial vertebral angiography(C) showed dilated arterial feeder, tangled vascular structures of nidus and arteriovenous shunting indicating brain AVM. Follow-up vertebral angiography(D) obtained in 27 months after radiosurgery showed still arteriovenous shunting (arrows) without abnormal tangled vessels.



가  
가  
10 T2  
(20)  
가  
5  
(20).  
가  
3  
(20).  
가  
T2  
가  
MRI  
AVM  
가  
T1  
가  
T2  
AVM  
가

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## Changes of MR Images in Arteriovenous Malformations of Brain after Gamma-knife Radiosurgery<sup>1</sup>

Eui Jong Kim, M.D., Woo Suk Choi, M.D., Young Jin Im, M.D.<sup>2</sup>,  
Joo Hyeong Oh, M.D., Kyung Nam Ryu, M.D., Yup Yoon, M.D.

<sup>1</sup>Department of Diagnostic Radiology, Kyung Hee University Hospital

<sup>2</sup>Department of Neurosurgery, Kyung Hee University Hospital

**Purpose:** To evaluate the changes in arteriovenous malformation(AVM) of the brain revealed by follow-up MR images after gamma-knife surgery.

**Materials and Methods:** In 25 patients with AVM of the brain who had undergone gamma-knife radiosurgery, 39 MR images were obtained during follow-up between 6 and 46 months later, and were reviewed. We evaluated changes volume of the nidus and in its enhancement patterns, changes in T1- and T2-weighted images of the regions in which the nidus had disappeared, and changes in adjacent brain. Conventional follow-up cerebral angiography was performed in seven patients, and the results were correlated with those obtained by MRI.

**Results:** On the MR images obtained as described, disappearance of signal void lesion within the nidus was observed in 16 of the 25 patients. In five of 16, the nidus was obliterated within 1 year of gamma-knife radiosurgery, and in the remaining 11 patients this happened after 1 year. In nine cases in which the nidus remained and 16 in which it was obliterated, follow-up examination of MR images revealed spot and mixed spot-nodular enhancement, with signal void lesion. Within the nidus, serial follow-up MR images showed increased enhancement, which was nodule-like. As seen on T1-weighted images, the lesions of obliterated nidus showed slightly lower or iso- signal intensity to gray matter in all 25 cases, while T2-weighted images revealed high signal intensity in 21 cases and iso-signal intensity in four. Abnormal high signal intensity adjacent to the brain was seen on T2 weighted images in nine of 25 cases. In six of seven cases in which cerebral angiography was performed, AVM was obliterated on both MRI and angiography. In one case, however, MR imaging showed that a signal void lesion remained. Cerebral angiography in this case revealed arteriovenous shunting.

**Conclusion:** After gamma-knife surgery, early follow-up revealed that in AVM of the brain, a spot and mixed spot and nodular enhancement pattern was visible, with a reduced volume of signal void lesions. During later follow-up, an enhanced nodular pattern was revealed. Nodular enhancement without signal void lesion probably indicates complete regression of the nidus of AVM.

**Index words :** Arteriovenous malformations, cerebral  
Brain, MR  
Cerebral angiography  
Brain, effects of irradiation on

Address reprint requests to : Eui Jong Kim, M.D., Department of Diagnostic Radiology, Kyung Hee University Hospital  
#1, Hoeki-dong, Dongdaemun-ku, Seoul, 130-702, Korea.  
Tel. 82-2-958-9760, 8625 Fax. 82-2-968-0787