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S J Kim, J H Lee and D C Suh

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# Cerebellar MR Changes in Patients with Olivary Hypertrophic Degeneration

Sang Joon Kim, Jae-Hong Lee, and Dae Chul Suh

**PURPOSE:** To describe MR changes in the cerebellar cortex and the dentate nucleus in patients with inferior olivary nucleus hypertrophy. **METHODS:** MR scans of 11 patients with palatal myoclonus were reviewed. Among them, we selected 5 cases that showed lesions in the central tegmental tract and the ipsilateral inferior olivary nucleus. We evaluated MR changes of the cerebellar cortices and dentate nuclei contralateral to the affected inferior olivary nuclei. Evaluation was performed by side-to-side comparison in each case. Six cases were excluded, because comparison of the cerebellar hemispheres or dentate nuclei with those of the opposite sides was not possible. **RESULTS:** The dentate nuclei opposite affected inferior olivary nuclei showed mild to moderate shrinkage of the normal low-signal areas and increases in signal intensity on T2-weighted images in 4 of 5 patients. The cerebellar cortices on the same sides as the involved dentate nuclei showed atrophic changes in 4 of 5 patients. **CONCLUSION:** Our MR findings suggest that there is a degenerative process involving the dentate nucleus and the cerebellar cortex associated with the hypertrophic degeneration of the inferior olivary nucleus.

**Index terms:** Cerebellum, atrophy; Brain stem; Cerebellum, magnetic resonance

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Magnetic resonance (MR) imaging has made it possible to show changes in neurodegenerative diseases involving the brain stem and cerebellum owing to the absence of beam-hardening artifact and the superior tissue contrast compared with computed tomography. In addition, the changes in the iron content of deep-seated nuclei can be seen with high-field MR. Cerebellorubral degeneration after resection of the cerebellar dentate nucleus may be an example (1) in which MR showed decreased size and increased signal intensity of the red nucleus on T2-weighted images. MR has made it possible to see hypertrophic degeneration of the inferior olivary nucleus in vivo in patients with lesions in the dentatorubroolivary tract; MR

findings of several cases have been described recently (2-6). Some animal experiments and human cases have revealed cerebellar degeneration after primary or secondary inferior olivary lesions (7-11).

We evaluated MR changes in the cerebellum and dentate nucleus associated with hypertrophic degeneration of the inferior olivary nucleus in patients with lesions in the central tegmental tracts.

## Patients and Methods

MR findings of 11 patients with palatal myoclonus were reviewed retrospectively. All MR examinations were done during the 21 months from January 1991 to September 1992. Among the 11 patients, we selected 5 in whom side-to-side comparison of the cerebellar hemispheres and dentate nucleus could be made in each patient on MR images. Six cases were excluded. Exclusion criteria were: (a) presence of preexisting lesions in the dentate nuclei, in which cases it was impossible to determine subsequent changes in the dentate nuclei (2 cases); (b) bilateral involvement of the inferior olivary nuclei, which made it impossible to compare the subsequent changes in the dentate nuclei and cerebellar cortices (3 cases); and (c) no definite high-signal changes in the inferior olivary nucleus or enlargement (1 case).

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From the Department of Radiology, College of Medicine, Dankook University (S.J.K.), Choong Nam, Korea; and the Departments of Radiology (D.C.S.) and Neurology (J.-H.L.), Asan Medical Center, University of Ulsan, Seoul, Korea.

Address reprint requests to Dae Chul Suh, MD, Department of Radiology, Asan Medical Center, University of Ulsan, 388-1 Poong Nap-Dong, Song Pa-Ku, Seoul 138-040, Korea.

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Summary of MR findings in patients with palatal myoclonus

Case	Age, y/Sex	Interval Between Ictus <sup>a</sup> and MR	CTT Lesion	ION Lesion, Size/Side	DN Change, Side/Size/SI	Cerebellum Atrophy
1	53/M	20 mo	L <sup>b</sup>	→/L	R/↓/↑	None
2	57/M	5 y	R	↑/R	L/↓/↑	L
3	53/M	3 mo	L	→/L	R/↓/↑	R
4	53/M	15 y	L	→/L	R/↓/↑	R
5	56/F	Unknown	R, C	↓/R	B/ND/↑	L

Note.—CTT indicates central tegmental tract; ION, inferior olivary nucleus; DN, dentate nucleus; SI, signal intensity on T2-weighted images; C, central; B, both; ND, not detectable; →, equivocal; ↑, increased; and ↓, reduced.

<sup>a</sup> Attack of responsible central tegmental tract lesion.

<sup>b</sup> Side of the lesion.

All five selected patients (four men and one woman; age range, 53 to 57 years; average age, 54.4 years) had lesions in the central tegmental tracts and in the ipsilateral inferior olivary nuclei on T2-weighted images. The central tegmental tract lesions were old hemorrhages, and the presumed underlying causes were hypertension in three and occult cerebrovascular malformations in two.

MR examinations were performed on a 1.5-T system. Axial and sagittal or coronal images (or both) were obtained, T1-weighted (500–600/20/1–3 [repetition time/echo time/excitations]) and T2-weighted (2000–2500/80–90/0.75–1). Section thickness was 5 to 6 mm, with an intersection gap 2.5 to 3 mm. The field of view was 200 mm, and the matrix size was 256 × 256 or 256 × 192.

We investigated hemispheric cerebellar atrophy and dentate nucleus shrinkage associated with the inferior olivary nucleus lesion. Cerebellar cortical atrophy was evaluated by comparing both hemispheres in each case on T2-weighted axial and/or T1-weighted coronal images. Asymmetric sulcal widening was used as a criterion of unilateral cerebellar atrophy. The size and signal intensity of the dentate nucleus were evaluated by comparing those in both hemispheres on T2-weighted axial images.

## Results

In all five patients the primary lesions were located in the ipsilateral central tegmental tracts. They were old hematomas seen as low-signal areas on T2-weighted images, revealing hemosiderin deposition, with or without a central high-signal portion. In two cases the central high signal was heterogeneous, and the peripheral hemosiderin rim was thick; they were thought to be occult cerebrovascular malformations. All five patients showed high signal intensity in the ipsilateral inferior olivary nucleus, but enlargement of the affected inferior olivary nucleus was variable: enlarged in one case, equivocal in three, and mildly atrophic in one. In the contralateral dentate nucleus, the low-signal area was smaller, and the signal intensity was higher than that of the ipsilateral side in four of

five cases. In one remaining case both dentate nuclei could not be delineated, and only mild high signal was noted in the dentate nucleus area contralateral to the inferior olivary nucleus lesion. Cerebellar cortices on the same side as the affected dentate nucleus showed mild to severe atrophic changes in four of five patients (Table and Figs 1 and 2). One case showed no atrophic changes in either cerebellar cortex.

## Discussion

Hypertrophic degeneration of the inferior olivary nucleus is known to be the underlying disease that causes symptoms of palatal myoclonus, that is, cyclic jerky movement of the soft palate. This specific type of degeneration is caused by a preceding lesion in the ipsilateral central tegmental tract or in the contralateral dentate nucleus (11–13). Since Lapresle and Hamida (12) proposed a triangular relationship between the red nucleus and inferior olivary nucleus on one side and the contralateral dentate nucleus as an explanation of the above association, the relationship between the three nuclei has been further clarified. The dentate nucleus projects to the contralateral red nucleus and thalamus through the superior cerebellar peduncle, which crosses the midline just below the red nucleus. The inferior olivary nucleus receives projections from the ipsilateral red nucleus through the central tegmental tract. The inferior olivary nucleus projects to the contralateral cerebellar cortex and deep nuclei through the inferior cerebellar peduncle (1, 8, 12–15) (Fig 3).

The pathway between the dentate nucleus and the inferior olivary nucleus through the inferior cerebellar peduncle was not considered significant in palatal myoclonus, because no lesion in the inferior cerebellar peduncle was



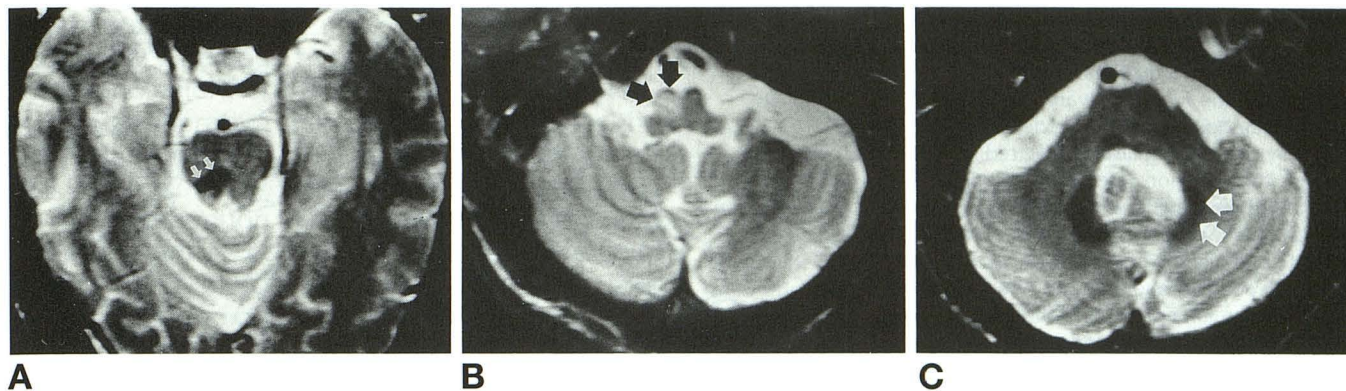


Fig 1. Case 2. Axial T2-weighted (2500/80/1) MR images in a 57-year-old man with an old pontine hemorrhage.

A, Scan at the level of the pons shows a hypointense lesion in the right tegmental area caused by hemosiderin deposit (*white arrows*).

B, At the level of the medulla, the right olive (*arrows*) reveals mild hypertrophy with high signal.

C, The left dentate nucleus (*white arrows*) is smaller and less hypointense than that of the opposite side, and left cerebellar cortical sulci are prominent.

observed to be associated with palatal myoclonus, and patients with lesions in the inferior cerebellar peduncles did not produce palatal myoclonus. The pathway from the dentate nucleus to the contralateral inferior olivary nucleus via the superior cerebellar peduncle was believed to be associated with palatal myoclonus or hypertrophic degeneration of the inferior olivary nucleus (12).

In our five patients with palatal myoclonus who had lesions in the inferior olivary nuclei and the central tegmental tracts, shrinkage of the cerebellar cortices and dentate nuclei contralateral to the affected inferior olivary nuclei was demonstrated.

Cerebellar cortical atrophy after injury to the inferior olivary nucleus has been reported in animal experiments and in humans (7, 8). A decrease in the number of Purkinje cells in the cerebellar cortex was reported in a patient with palatal myoclonus who had a lesion in the ipsilateral dentate nucleus and contralateral inferior olivary nucleus hypertrophy (10). A case was reported that showed "pallor" in the dentate nucleus at autopsy in a patient who had a lesion in the central tegmental tract and a hypertrophied inferior olivary nucleus (11). MR findings of our patients and the above-cited pathologic reports suggest that there is a degenerative process involving the cerebellum as a result of the infe-

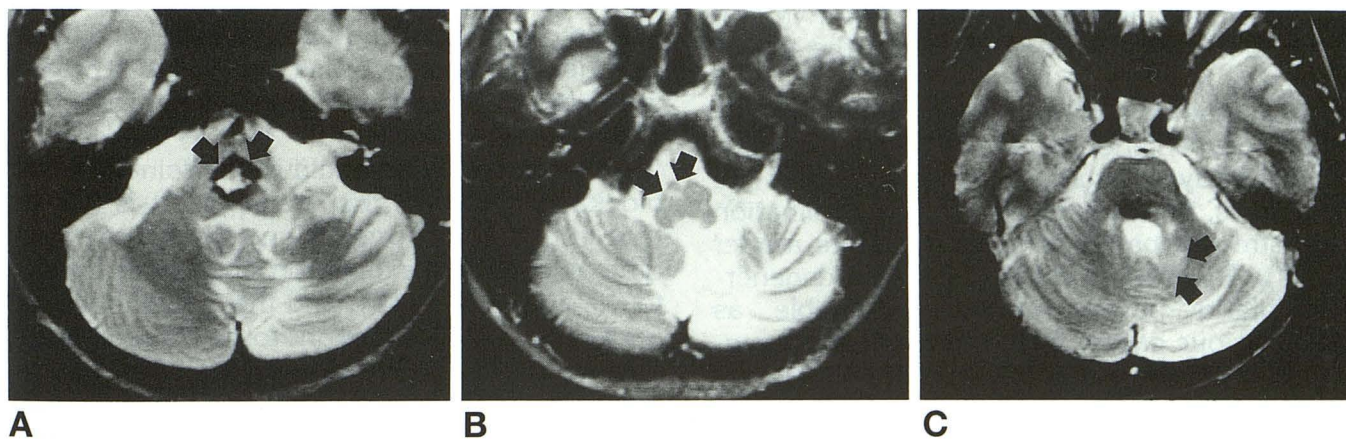


Fig 2. Case 5. Axial T2-weighted (2500/80/1) images in a 56-year-old woman with a presumed occult cerebrovascular malformation.

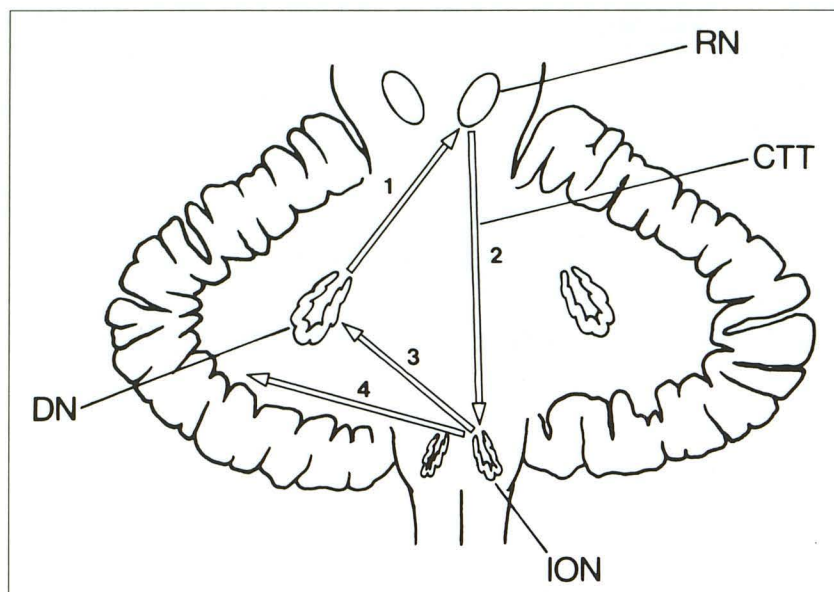
A, Scan at the level of the pons shows a round hypointense lesion with internal high signal in the lower pontine tegmentum (*arrows*); the left cerebellar hemisphere demonstrates severe atrophic change.

B, At the level of the medulla, the right olive (*arrows*) shows linear high signal but seems to be atrophic compared with the left side.

C, At the level of the dentate nucleus, both dentate nuclei could not be delineated; instead, subtle high signal is seen in the left dentate nucleus area (*arrows*).



Fig 3. Schematic drawing of the brain stem and cerebellum showing the relationship between the dentate nucleus (DN), the red nucleus (RN), the inferior olivary nucleus (ION), and the cerebellar cortex. The dentate nucleus projects to the contralateral red nucleus through the superior cerebellar peduncle. The inferior olivary nucleus receives projections from the red nucleus through the central tegmental tract (CTT) and projects to the contralateral dentate nucleus and the cerebellar cortex via the inferior cerebellar peduncle. The inferior olivary nucleus undergoes secondary hypertrophic degeneration after lesions in the contralateral dentate nucleus (1) or the ipsilateral central tegmental tract (2). Further changes occur in the dentate nucleus and the cerebellar cortex opposite the degenerated inferior olivary nucleus (3 and 4).



rior olivary nucleus lesion. The likely pathway is the olivocerebellar or olivodentate fibers located in the inferior cerebellar peduncle opposite the inferior olivary nucleus, which are efferent fibers from the inferior olivary nucleus to the cerebellar cortices and deep nuclei. In this regard, the tract from the inferior olivary nucleus to the dentate nucleus seems to work in patients with palatal myoclonus, although it may not contribute directly to the generation of palatal myoclonus (Fig 3). Although our five patients had lesions in the pons, the pathway to the cerebellum seems to be different from that of olivopontocerebellar atrophy, in which the ventral parts of the pons are typically involved (16); in our cases the lesions were confined to the dorsal parts.

Histopathologic changes in the hypertrophic degenerated inferior olivary nucleus are neuronal cell body enlargement, vacuolation of the nerve cells, fibrillary gliosis, and demyelination and astrocyte proliferation of the white matter (2, 11). The size of the hypertrophic degenerated inferior olivary nucleus is variable, as shown in our cases. Birbamer et al (17) suggested that this variability is time-dependent based on their MR investigation (17); that is, no abnormal MR findings in the acute stage, enlargement after a variable time interval, and, finally, a return to normal size in a late stage. This was not exactly true in our cases, and there seems to be wide individual variation.

The reduction in size with a slight increase of signal intensity in the dentate nucleus in our

cases might be caused by iron depletion in the nucleus, although it was not proved pathologically. Normally, the dentate nucleus appears as a crescent-shaped low-signal-intensity structure on T2-weighted images just posterolateral to the fourth ventricle. Its low signal is explained as a result of physiologic iron accumulation (18). Various degenerative diseases involving the central nervous system are associated with an increase in brain iron deposition (ie, Hallervorden-Spatz disease, Huntington disease, Parkinson disease, Alzheimer disease) (19). However, in some instances, decreased iron content in the nucleus is known to occur in certain neurodegenerative diseases. Similar changes of signal increase and a size decrease in the red nucleus were reported after resection of the dentate nucleus (1).

The iron depletion could be explained by the blockage of axonal iron transport. It is known that iron is transported along the  $\gamma$ -aminobutyric acid-related axons from the site of uptake to the site of use (19), and the  $\gamma$ -aminobutyric acid-related link is thought to be present in the olivocerebellar loop (20). In case of damage to the pathway of axonal transport, the iron accumulation in the region of high iron concentration could be reduced. Damage to the inferior olivary nucleus might have blocked the transport of iron to the dentate nuclei in our cases. Another possible mechanism of decreased size of the dentate nucleus is loss of cells in the nucleus, although no loss of cells was reported



in an autopsy specimen study from patients with olivary nucleus hypertrophy (11).

In conclusion, our findings suggest that neuronal degenerative change might occur in the cerebellum after hypertrophic degeneration of the inferior olivary nucleus and be manifested on MR as reduction in size and increase in signal intensity of the contralateral dentate nucleus and atrophy of the cerebellar cortex on that side. These findings were consistent in patients with palatal myoclonus, except in cases in which side-to-side comparison of the cerebellar cortices or dentate nuclei was not possible.

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