CLINICAL IMAGE

Usefulness of MR Imaging in Idiopathic Oculomotor Nerve Palsy Cases: \( T_2 \)-weighted IDEAL

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Introduction

Patients with oculomotor nerve palsy (ONP) have clinical symptoms of diplopia and/or blepharoptosis. Herein, we identified damaged oculomotor nerves with \( T_2 \)-weighted (\( T_2W \)) interactive decomposition of water/fat using echo asymmetry and least-squares estimation (IDEAL) imaging, a kind of fat-suppression imaging, and a variant of 3-point Dixon method, in idiopathic ONP patients.

Case Reports

We encountered eight patients with idiopathic ONP and used \( T_2W \) IDEAL imaging (Signa HDxt 3.0T; GE Healthcare, Milwaukee, WI, USA) to visualize their oculomotor nerves. The repetition and echo times of the \( T_2W \) images shown were 3400–4483.34 ms and 81.79–86.3, respectively, in IDEAL images. Radiologists were not given any information about which side of oculomotor nerve was impaired. We reviewed their clinical symptoms and results of their examinations (Table 1). Here, we present a normal control (Fig. 1a) and two representative cases.

Case 1

A 43-year-old female was admitted because of double vision. A 1.5T brain MRI did not detect any abnormalities. The patient’s eye movement was impaired in all directions. In \( T_2W \) IDEAL images obtained with 3T MRI, the left oculomotor nerve itself showed high signal intensity (Fig. 1b). We found gadolinium enhancement of the left oculomotor nerve.

Case 2

A 23-year-old male was admitted due to acute-onset double vision. We confirmed the right eye’s outward deviation. \( T_2W \) IDEAL images revealed that 15 mm of the right oculomotor nerve was swollen with high signal intensity from the cavernous sinus to the orbital apex (Fig. 1c) and that the nerve showed gadolinium enhancement (Fig. 1d). The right medial (MR) and inferior rectus (IR) muscles demonstrated high signal intensity on \( T_2W \) IDEAL imaging (Fig. 1e).

Discussion

Upon MRI, all eight idiopathic ONP patients showed high signal intensities on their oculomotor nerves. We administered gadolinium to six of the ONP patients and all of them showed enhancement. Steroid pulse therapies which we prescribed for seven of the idiopathic ONP patients were effective. However, after their therapies, only two ONP patients showed improvement in their oculomotor nerves upon MRI (Table 1).

Although the oculomotor nerve is less than 1 mm thick, we were able to detect the affected oculomotor nerves with higher signal intensity in idiopathic ONP patients by using \( T_2W \) IDEAL images in thin slices (2.5–3.0 mm) of coronal sections. Compared to short-tau inversion recovery and fluid-attenuated inversion recovery imaging, damaged oculomotor nerves in ONP patients showed higher intensity than other orbital tissues, another healthy oculomotor nerve, and optic nerves on \( T_2W \) IDEAL images. This protocol also showed increased signal intensity of extraocular muscles which might have reflected denervation of the oculomotor nerve (Fig. 1e). We also found that gadolinium-enhanced images were useful to detect damaged oculomotor nerves.

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Table 1 Clinical characteristics of patients with idiopathic oculomotor nerve palsy with abnormal MRI findings

|                  | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 |
|------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Age (M/F)        | 43 (F) | 23 (M) | 59 (F) | 55 (F) | 84 (F) | 40 (F) | 55 (M) | 59 (M) |
| Prodromal infection | Yes   | No    | No    | No    | Yes   | No    | No    | No    |
| Initial symptoms | Diplopia | Diplopia | Blepharoptosis | Diplopia | Blepharoptosis, Diplopia | Diplopia | Blepharoptosis | Diplopia |

Oculomotor abnormality
- **Affected side(s)**
  - Case 1: L²
  - Case 2: R
  - Case 3: R
  - Case 4: L
  - Case 5: R < L³
  - Case 6: L
  - Case 7: L
  - Case 8: R

- **Anisocoria**
  - Case 1: Yes
  - Case 2: No
  - Case 3: No
  - Case 4: No
  - Case 5: No
  - Case 6: Yes
  - Case 7: No
  - Case 8: No

- **Light reflex**
  - Case 1: Impaired
  - Case 2: Impaired
  - Case 3: Impaired
  - Case 4: No
  - Case 5: No
  - Case 6: No
  - Case 7: No
  - Case 8: Impaired

- **Eye movement**
  - Case 1: Impaired
  - Case 2: Impaired
  - Case 3: Impaired
  - Case 4: Impaired
  - Case 5: Impaired
  - Case 6: Impaired
  - Case 7: Impaired
  - Case 8: Impaired

- **Blepharoptosis**
  - Case 1: No
  - Case 2: No
  - Case 3: Yes
  - Case 4: No
  - Case 5: Yes
  - Case 6: No
  - Case 7: No
  - Case 8: Yes

- **Other neurological findings**
  - Case 1: No
  - Case 2: No
  - Case 3: No
  - Case 4: No
  - Case 5: No
  - Case 6: No
  - Case 7: No
  - Case 8: No

- **Abnormal immunity**
  - **Autoantibodies**
    - Case 1: Yes
    - Case 2: Yes
    - Case 3: No
    - Case 4: No
    - Case 5: No
    - Case 6: Yes
    - Case 7: No
    - Case 8: No

- **Diabetes mellitus**
  - Case 1: No
  - Case 2: No
  - Case 3: No
  - Case 4: No
  - Case 5: No
  - Case 6: No
  - Case 7: No
  - Case 8: No

- **CSF findings (cells/µl/protein [mg/dl])**
  - Case 1: 6/31
  - Case 2: 3/25
  - Case 3: 9/32
  - Case 4: 0/45
  - Case 5: 0/48
  - Case 6: n.d.⁴
  - Case 7: 4/70
  - Case 8: 0/39

- **MRI findings of the oculomotor nerve**
  - **High signal on T₂W IDEAL image (R/L)**
    - Case 1: −/L
    - Case 2: R > L
    - Case 3: R/−
    - Case 4: −/L
    - Case 5: R < L
    - Case 6: −/L
    - Case 7: −/L
    - Case 8: R/−

  - **Location of high signal**
    - Case 1: A–C
    - Case 2: A–C
    - Case 3: A–C, CS
    - Case 4: A–C
    - Case 5: A–C, CS
    - Case 6: A–C
    - Case 7: A–C
    - Case 8: A–C

  - **Enhancement with Gd (R/L)**
    - Case 1: −/L
    - Case 2: R > L
    - Case 3: R/−
    - Case 4: −/L
    - Case 5: n.d.
    - Case 6: n.d.
    - Case 7: −/L
    - Case 8: R/−

- **Abnormality of extraocular muscles**
  - Case 1: Yes
  - Case 2: Yes
  - Case 3: No
  - Case 4: Yes
  - Case 5: Yes
  - Case 6: Yes
  - Case 7: No
  - Case 8: Yes

- **Response to steroid**
  - Case 1: Good
  - Case 2: Complete
  - Case 3: Complete
  - Case 4: Good
  - Case 5: Good
  - Case 6: Good
  - Case 7: Complete
  - Case 8: Complete

- **Tx⁹ courses required**
  - Case 1: 4
  - Case 2: 3
  - Case 3: 3
  - Case 4: 3
  - Case 5: Oral
  - Case 6: PSL
  - Case 7: 1
  - Case 8: 5

- **Recurrence after Tx**
  - Case 1: No
  - Case 2: No
  - Case 3: No
  - Case 4: No
  - Case 5: Yes (2 m)
  - Case 6: No
  - Case 7: No
  - Case 8: Yes (3 y)

- **MRI findings after Tx**
  - Case 1: Improved
  - Case 2: Unchanged
  - Case 3: Improved
  - Case 4: Unchanged
  - Case 5: Unchanged
  - Case 6: n.d.
  - Case 7: n.d.
  - Case 8: Unchanged

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¹Only the side of the oculomotor nerves showing abnormal findings are indicated; L and R indicate the side of the oculomotor nerve affected.
²R < L indicates the left oculomotor nerve affected more severely than the right, and R > L indicates vice versa. n.d.: not done.
³A–C: the marginal area between the orbital apex and cavernous sinus.
⁴CS: the cavernous sinus area.
⁵Good, Complete: We defined the terms to evaluate the responsiveness to steroid pulse therapies in the acute phase; “complete” meant recovery to their original oculomotor function, “good” meant recovery without diplopia in daily life.
⁶Tx: therapies. PSL: prednisolone 20 mg/day.

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Fig. 1 The repetition and echo time of the T₂-weighted (T₂W) images shown were 3400–4483.34 ms and 81.79–86.3, respectively, in T₂W IDEAL images. (a) MRI T₂W IDEAL images (a serial of coronal section) in a normal control. Each arrowhead indicates oculomotor nerves and are demonstrated as iso-signal intensities. V1: ophthalmic nerve, V2: maxillary nerve, VI: abducens nerve. (b) MRI T₂W IDEAL image (coronal section) of the head in Case 1—the left oculomotor nerve demonstrated high signal intensity. (c) MRI T₂W IDEAL image (coronal section) of the head in Case 2—the left oculomotor nerve demonstrated high signal intensity. (d) MRI post-contrast T₁W IDEAL image (coronal section) in Case 2. The right oculomotor nerve demonstrated contrast enhancement. The TR and TE were 583 and 10 ms, respectively, in post-contrast fat-saturated T₁W image. (e) The right medial (MR) and inferior rectus (IR) muscles also demonstrated high signal intensities.
high intensity from the orbital apex to the cavernous sinus. The narrow structure and venous plexus are anatomical reasons why the oculomotor nerve can be damaged by any type of inflammation and occlusion. Furthermore, we suspect that an aberrant immune response might have been involved in ONP patients because steroid pulse therapy was effective.

Author Contributions

H. Nakajima (Nagasaki, Japan) collected the clinical data from patients and wrote the article, M. Motomura, T. Ando, A. Kawakami, and A. Tsujino (Nagasaki, Japan) analyzed the clinical data and supervised the study, M. Morikawa (Nagasaki, Japan) evaluated and analyzed MR images.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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