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Case Report

MRI of cranial nerve enhancement: King Chulalongkorn Memorial Hospital (KCMH) case series

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Abnormal enhancement of cranial nerves (CNs) can be observed in a variety of disease. We present eight cases of cranial nerve (CN) enhancement, including inflammatory process, hematologic malignancy, perineural spreading of extracranial tumor, cerebrospinal fluid seeding of high grade primary brain tumor, demyelination and post radiation change. Based on our case series, the findings cover board differential diagnoses. The use of contrast enhanced 3-dimensional (3D) T1-weighted image (T1WI) magnetic resonance imaging (MRI) and reasonable MRI sequences can increase conspicuity of the finding. Furthermore, incorporating underlying disease, clinical duration, and associated intracranial / extracranial findings may help narrow the probable etiologies.

Keywords: Abnormal enhancement of cranial nerves (CNs), 3-dimensional (3D) T1-weighted image (T1WI), magnetic resonance imaging (MRI).

Magnetic resonance imaging (MRI) is invaluable in characterizing the diseases involving cranial nerves (CNs). The 3-dimensional (3D) T1-weighted image (T1WI) with gadolinium administration increases the ability of MRI to detect these subtle abnormalities. The CNs are surrounded by a series of connective tissue sheaths called endoneurium, perineurium, and epineurium. The blood-nerve barrier of CNs is maintained by the combined actions of tight junctions in the endothelium of the endoneural capillaries and tight junctions in the inner layers of the perineurium. Various insults disrupt the blood-nerve barrier, allowing leakage and accumulation of contrast material with resultant perineural enhancement. Such disruption may arise secondary to neoplasm, autoimmune disease, inflammation, demyelination, ischemia, trauma, radiation, and axonal degeneration, all results in abnormal CN enhancement on post gadolinium magnetic resonance imaging (MRI). [1, 2]

There are instances of normal CN enhancement. The geniculate, tympanic, and mastoid segments of the facial nerve possess peri- and epineural venous plexuses that may cause moderate enhancement by increased vascular pool of contrast materials. The intracanalicular–labyrinthine segment does not normally enhance. The trigeminal ganglion and the proximal portions of its divisions are seen as discrete non enhanced structures surrounded by an enhancing perineural vascular plexus. [2]

We reviewed a series of cases with abnormal CN through MRI enhancement at King Chulalongkorn Memorial Hospital (KCMH). In some cases, abnormal CN enhancement of MRI may be the only clue to the underlying disease.

Case series

We reviewed a series of MRI of abnormal CN enhancement from Department of Radiology, KCMH, from August 2010 to January 2018. Final diagnosis in each patient was made with clinical information, laboratory findings, specific investigation, and/or histopathology.

Case 1:

A 65-year-old male presented with left facial paralysis for 2 days. He had no known underlying disease. Bell's palsy was suspected on clinical basis. MRI of the brain with gadolinium contrast (Figure 1) demonstrated asymmetrical prominent smooth enhancement of left facial nerve, involving from distal internal auditory canal (IAC) down to mastoid segment. No other imaging abnormality was detected.

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Bell's palsy was diagnosed. The patient was treated with physical therapy, corticosteroids and antiviral agents. After 1 week of treatment, the patient responsed to treatment with clinical improvement.

Bell's palsy occurs when the facial nerve becomes swollen or compressed, resulting in facial weakness or paralysis. The exact cause of this damage is unknown, but many medical researchers believe it is most likely triggered by a viral infection. Bell's palsy is purely clinical diagnosis. Abnormal enhancement of IAC segment of facial nerve can be demonstrated on gadolinium contrast T1WI, although nonspecific finding, imaging may help excluding other pathological process affecting facial nerve. [2]

Case 2:

A 43-year-old HIV-positive female patient presented with 2 weeks of progressive headache. The physical examination showed bilateral CN III and CN V palsy. The axial MRI of the brain post gadolinium T1WI (Figure 2) revealed abnormal enhancement and smooth thickening of bilateral CN III, thick enhancement of bilateral Meckel's caves and asymmetrical prominent enhancement of left foramen ovale. B-cell non-Hodgkin's lymphoma was found from the cerebrospinal fluid (CSF) cytology.

CN involvement in lymphoma ranges from compression to invasion, and also antero - and retrograde spread can occur. Interestingly also anastomoses between nerves can serve tumor spread from one nerve distribution into the other (e.g. facial nerve and CN V, cervical plexus and occipital nerves). Specific spread restricted to CN and peripheral nerves is termed neurolymphomatosis (NL). NL is a rare condition, usually by B-cell lymphoma, which shows enlargement and enhancement of affected CN on MRI. A combination with leptomeningeal spread can occur. [3, 4]

Case 3:

A 45-year-old male presented with 2 months of bilateral amblyopia and suspected bilateral CN III palsy. He had underlying of acute myeloid leukemia (AML). MRI of the brain with gadolinium contrast (Figure 3) demonstrated thick enhancement along bilateral CN III, CN V, CN VIII, facial nerves, anterior labyrinthine segment of left facial nerve and bilateral foramen ovale. The patient underwent bone marrow biopsy and histopathology access to acute leukemia. Relapsed AML with CN involvement was diagnosed.

Perineural involvement can occur in lymphoblastic leukemia and non-Hodgkin's lymphoma. MRI findings of perineural involvement included smooth thickening and enhancement of the nerve, concentric expansion of the skull base foramina with obliteration of normal fatty contents, enlargement of the cavernous sinus, and might be neuropathic muscular atrophy.[2]

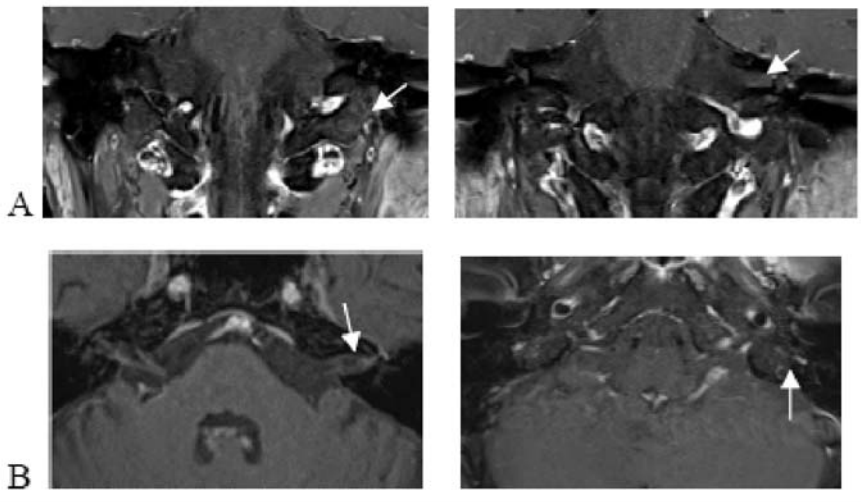

Figure 1. Case 1: Bell's palsy: A 65-year-old male presented with left facial paralysis for 2 days. He had no known underlying disease. Bell's palsy was suspected on the clinical examination. MRI of the brain coronal (A) and axial (B) post gadolinium T1WI demonstrated asymmetrical prominent smooth enhancement of left facial nerve, involvingfrom left distal IAC down to mastoid segment (white arrow).

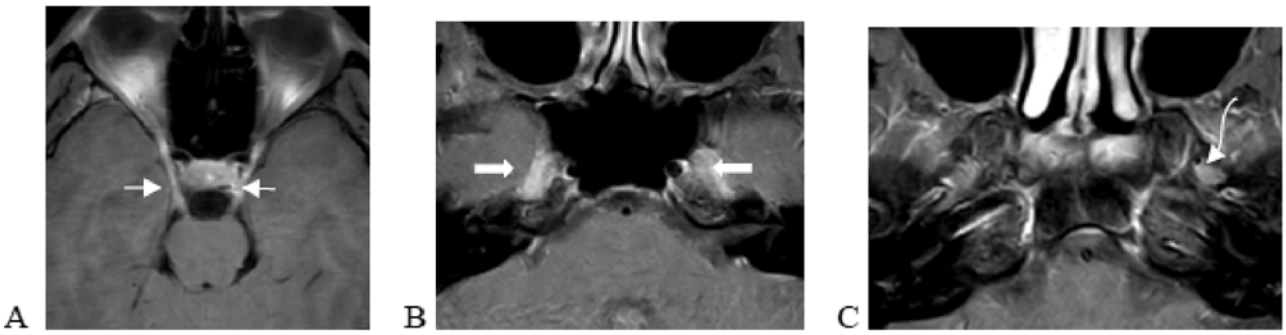

Figure 2. Case 2: lymphoma with CN involvement: A 43-year-old HIV-positive female patient presented with 2 weeks of progressive headache with bilateral CN III and CN V palsy. MRI of the brain axial post gadolinium T1WI demonstrated abnormal enhancement and smooth thickening of bilateral CN III (A, white arrows), thick enhancement of bilateral Meckel caves (B, white thick arrows) and asymmetrical prominent enhancement in left foramen ovale (C, white curve arrow).

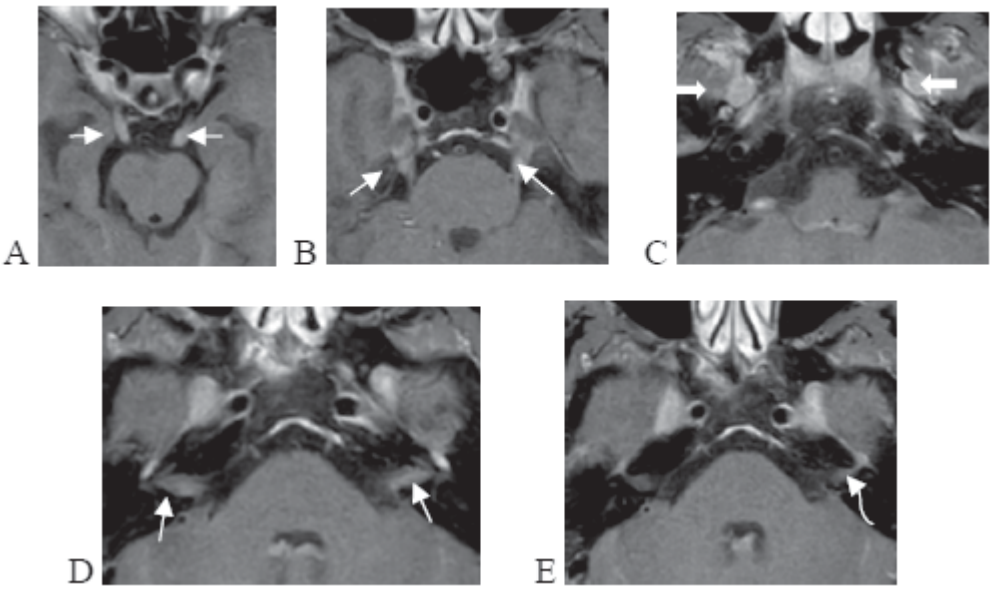

Figure 3. Case 3: acute myeloid leukemia (AML) with CN involvement: A 45-year-old male presented with 2 months of bilateral amblyopia and suspected bilateral CN III palsy. He had underlying of AML. MRI of the brain axial post gadolinium T1WI demonstrated thick enhancement along bilateral CN III, CN V, CN VIII, facial nerves (A, B and D, respectively, white arrows), anterior labyrinthine segment of left facial nerve (E, curve arrow) and bilateral foramen ovale (C, thick white arrows).

Case 4:

A 57-year-old male presented with 2 months of palpable left parotid mass. MRI of the nasopharynx with gadolinium contrast (Figure 4) shows ill-defined infiltrative lesion in left parotid gland involving the whole gland with tumor extension into posterior left cavernous sinus and Meckel cave, by perineural extension along mandibular branch of left CN V via left auriculotemporal nerve behind the mandibular angle. Findings of acute denervation the left muscles of mastication also found. Biopsy of the lesion in left parotid gland was performed. Histopathology revealed basal cell adenocarcinoma of parotid gland with perineural invasion.

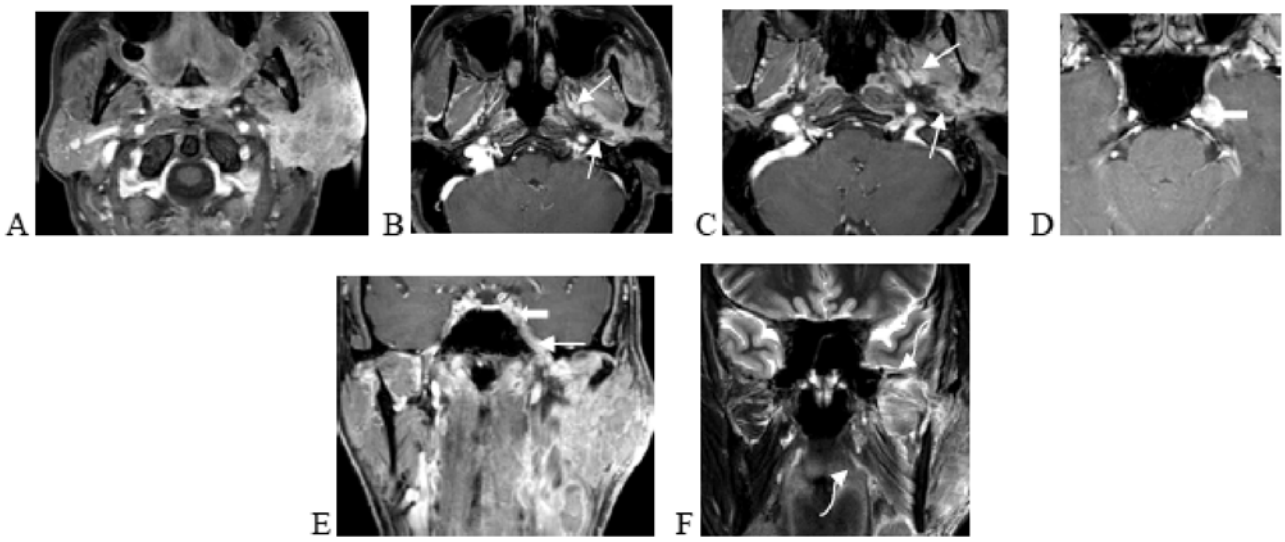

Figure 4. Case 4: perinural tumor spread (PNS): A 57-year-old male presented with 2 months of palpable left parotid mass. MRI of the nasopharynx axial (A, B, C and D) coronal (E) post gadolinium T1WI and coronal T2WI (F) shows ill-defined heterogeneously enhancing infiltrative lesion involving entire left parotid gland (A) with tumor extension into posterior left cavernous sinus and Meckel cave (D and E, thick white arrows) by along mandibular branch of left CN V and via left auriculotemporal nerve behind the mandibular angle (B, C and E, white arrows) together with evidence of denervation of muscles of mastication on the left side (F, curve arrow).

Perineural invasion (PNI) is defined as tumor cells within any of the 3 layers of the nerve sheath (epineurium, perineurium, and endoneurium) or tumor cells surrounding at least 33% of the nerve. PNI is inconsistently visualized radiographically. In contrast, perineural tumor spread (PNS), defined as dissemination of the main tumor along the CN, is often radiographically detectable, even before patients become symptomatic. Adenoid cystic carcinoma (ACC) of the minor or major salivary glands is the tumor most likely developed PNS, with a prevalence of up to 56%. However, because ACC is a rare tumor, it accounts only for a small number of patients reported with PNS. The highest number of PNS is diagnosed in patients with squamous cell carcinoma because it is the most common head and neck cancer even though it has lower propensity for neural involvement than ACC. Additional tumors that may develop PNS include mucoepidermoid and basal cell carcinomas, as well as desmoplastic melanomas, sarcomas, and lymphomas.[5]

PNS typically manifests as enhancement of the involved nerve. Often this is associated with enlargement of the affected nerve, however, sometimes, the nerve remains normal in size, making it difficult for the radiologist to detect the PNS. PNS can lead to denervation of the muscles supplied by the involved nerve.[5]

Case 5:

A 58-year-old male, known case of glioblastoma status post surgery and chemoradiation. He presented with diplopia and was found to have right oculomotor nerve palsy on physical examination. MRI of the brain with gadolinium contrast (Figure 5) demonstrated mild thick enhanced lesion along bilateral CN III, and pituitary infundibulum, fovered leptomeningeal seeding. There is thick irregular rim enhancing lesion involving the left occipito-parietal lobe and left choroid plexus, suggested residual or recurrent glioblastoma with area of necrosis.

Leptomeningeal seeding or metastasis refers to the dissemination of cancer to the arachnoid mater, CSF, and pia mater, which occurs in approximately 5% to 8% of all patients with cancer. The most common cancers that result in leptomeningeal metastasis include lung cancer, breast cancer, and melanoma. Acute lymphoblastic leukemia (ALL), non-Hodgkin lymphoma (NHL), and high grade primary brain tumor can also develop leptomeningeal involvement or leptomeningeal seeding. As for the evaluation of leptomeningeal seeding or metastasis, gadolinium contrast-enhanced T1WI and fluid attenuated inversion recovery (FLAIR) studies offer the best imaging method.[6 - 8]

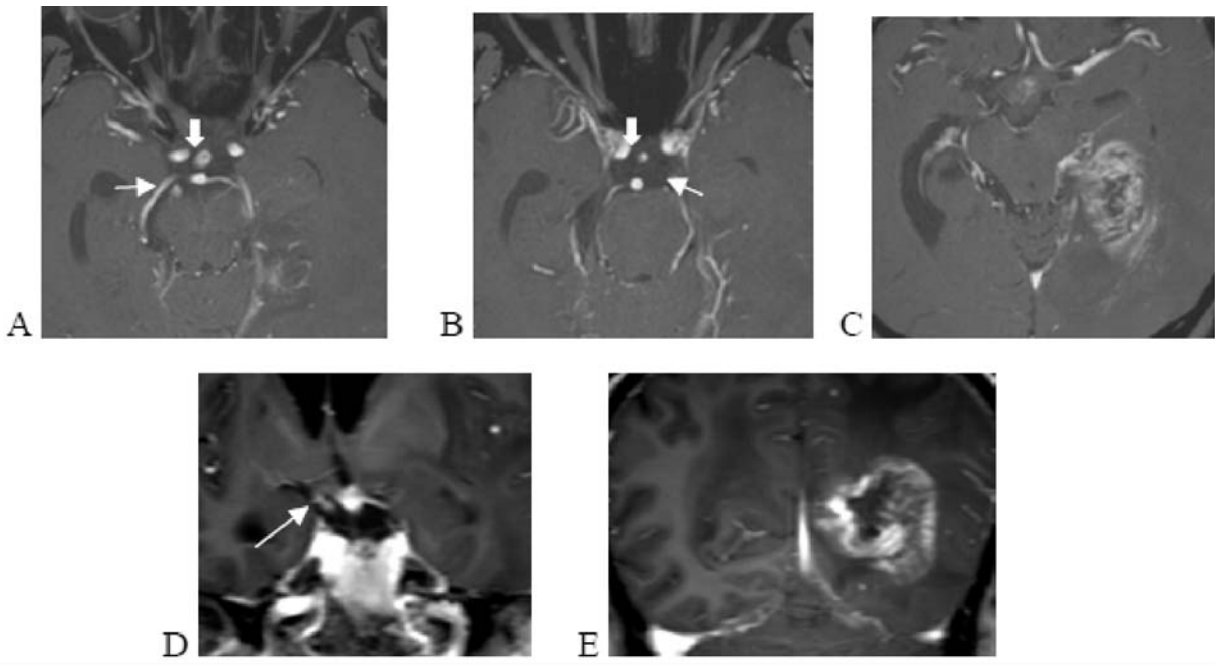

Figure 5. Case 5: glioblastoma with leptomeningeal seeding: A 58-year-old male, known case of glioblastoma status post surgery and chemoradiation. He presented with diplopia and was found to have right oculomotor nerve palsy on physical examination. MRI of the brain axial (A, B, and C) and coronal (D and E) post gadolinium T1WI shows abnormally thickened enhancement along bilateral CN III (A, B and D, white arrow), and pituitary infundibulum (A and B, white thick arrow), suggested leptomeningeal seeding. There is irregular rim enhancing lobulated lesion or residual / recurrent glioblastoma with area of necrosis and post treatment change involved left occipito-parietal lobe and left choroid plexus (C and E).

Glioblastoma is the most common primary malignancy of the CNS in the adult. Leptomeningeal seeding is observed in approximately 15 - 25% of cases of supratentorial glioma. MRI of leptomeningeal seeding range from diffuse linear leptomeningeal enhancement to multiple enhancing extra-axial nodules covering the surface of the brain, CN, and ventricular system.[7]

Case 6:

A 28-year-old male presented with diplopia, limb weakness and visual loss for 1 day. MRI of the brain and orbits with gadolinium contrast (Figure 6) demonstrated enhancement along cisternal portion of bilateral CN III, CN V and CN VI. There is no abnormal signal intensity or enhancement of the brain and/or optic pathway. The MRI findings together with clinical, physical examination and laboratory finding of positive serum anti-GQ1b antibody made Miller-Fisher syndrome the most likely diagnosis. The patient was treated with IVIG and had clinical improvement after 1 week of treatment.

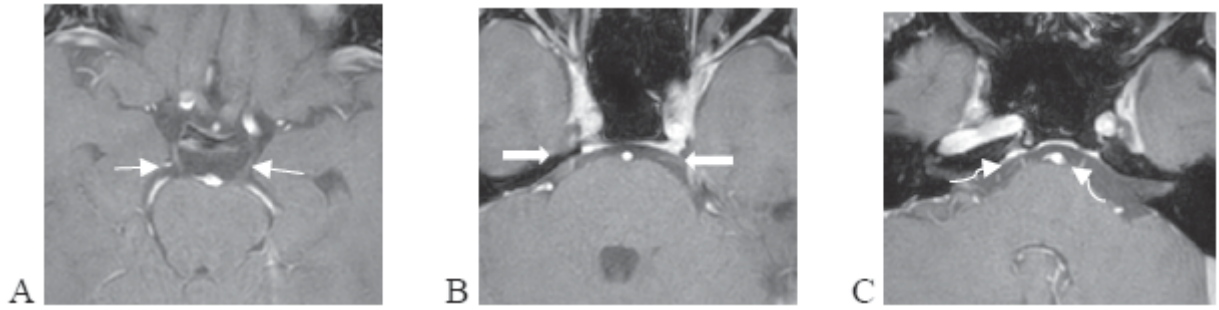

Figure 6. Case 6: Miller-Fisher syndrome (MFS): A 28-year-old male presented with diplopia, limb weakness and visual loss for 1 day. Axial MRI of the brain and orbits post gadolinium T1WI shows enhancement along cisternal portion of bilateral CN III (A, white arrow), CN V (B, white thick arrow) and CN VI (C, curve arrow).

Miller-Fisher syndrome (MFS) was described in 1956 and it has been considered a variant of Guillain Barré syndrome (GBS). [9] The syndrome is characterized by a triad of acute gait ataxia, ophthalmoplegia, and areflexia. Majority of MFS cases were associated with a non-specific pathogen that causes upper respiratory tract infection. MFS can frequently follow a variety of infections, including Campylobacter jejuni (21%) and haemophilus influenza (8%).[10]

Several studies showed evidence supported molecular mimicry between ganglioside GQ1b, a major composition of myelin in peripheral nerve and lipopolysaccharide in some infectious agents especially Campylobacter jejuni. Ganglioside GQ1b is abundantly detected in cranial nerve III, IV, VI, optic nerve, dorsal root ganglia, presynaptic neuromuscular junction and anti-GQ1b antibody has been detected in MFS and GBS patients who had ophthalmoplegia as well as optic neuropathy.[10 - 12]

Case 7:

A 42-year-old male presented with a 1 year of progressive left ptosis and ophthalmoplegia. MRI of the brain and the orbits with gadolinium contrast (Figure 7) demonstrated abnormal enlargement of the intracavernous portions of bilateral CN III continuous into bilateral orbital apices, predominately on the left.

The patient underwent nerve biopsy and histopathology reveals chronic neuropathy. Electromyography and nerve conduction study demonstrate demyelinating disease involved both sensory and motor nerve including slowed motor nerve conduction velocity, prolonged distal motor latency and abnormal temporal dispersion, when combined with the onset of disease and MRI findings, it was diagnosed as a chronic inflammatory demyelinating polyneuropathy (CIDP). After treatment of corticosteroid for 2 weeks, the patient responded to treatment and clinically improvement.

CIDP is a neurological disorder characterized by progressive weakness and impaired sensory function in the legs and arms. The disorder, which is sometimes called chronic relapsing polyneuropathy, is caused by damage to the myelin sheath (the fatty covering that wraps around and protects nerve fibers) of the peripheral nerves. Although it can occur at any age and in both genders, CIDP is more common in young adults, and in men more so than women.[13] CIDP develops over at least 2 months and diagnosis is mainly based on physiologic and cerebrospinal fluid (CSF) studies. The response to intravenous immunoglobulins, corticosteroids, and other immunosuppressants is also a key feature of CIDP.[14, 15]

Predominant CN involvement is a relatively unusual feature of CIDP, being described in only 5% of patients in a case series. CN III, CN IV and CN VI are most often affected, followed by the facial nerve, and, more rarely, CN IX, CN X, and CN XI.[14, 15]

Case 8:

A 33-year-old male, known case of right basal ganglia germinoma underwent surgery and radiation 10 years ago. The patient was doing well and MRI brain was performed as a part of routine surveillance. MRI of the brain post gadolinium contrast T1WI (Figure 8) demonstrated smooth enhancement of cisternal portion of bilateral CN IIIs, no change from prior study done 2 years ago. Area of prior tumor involvement in right basal ganglia remained as parenchymal volume loss and hemosiderin deposition. The patient had no clinical symptom, together with the MRI findings and physical examination, favored CN III enhancement due to post radiation.

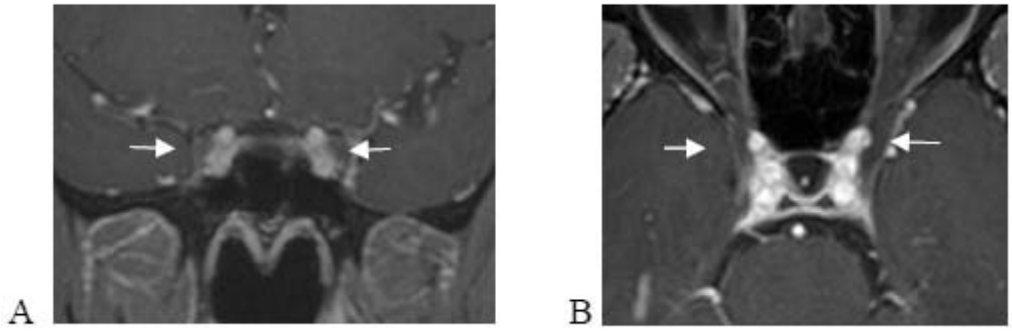

Figure 7. Case 7: chronic inflammatory demyelinating polyneuropathy (CIPD): A 42-year-old male presented with a 1 year of progressive left ptosis and ophthalmoplegia. Coronal (A) and axial (B) MRI of the brain and orbits post gadolinium T1WI shows abnormal enlargement of the intracavernous portions of bilateral CN III continuous to bilateral orbital apices, predominately on the left (white arrow).

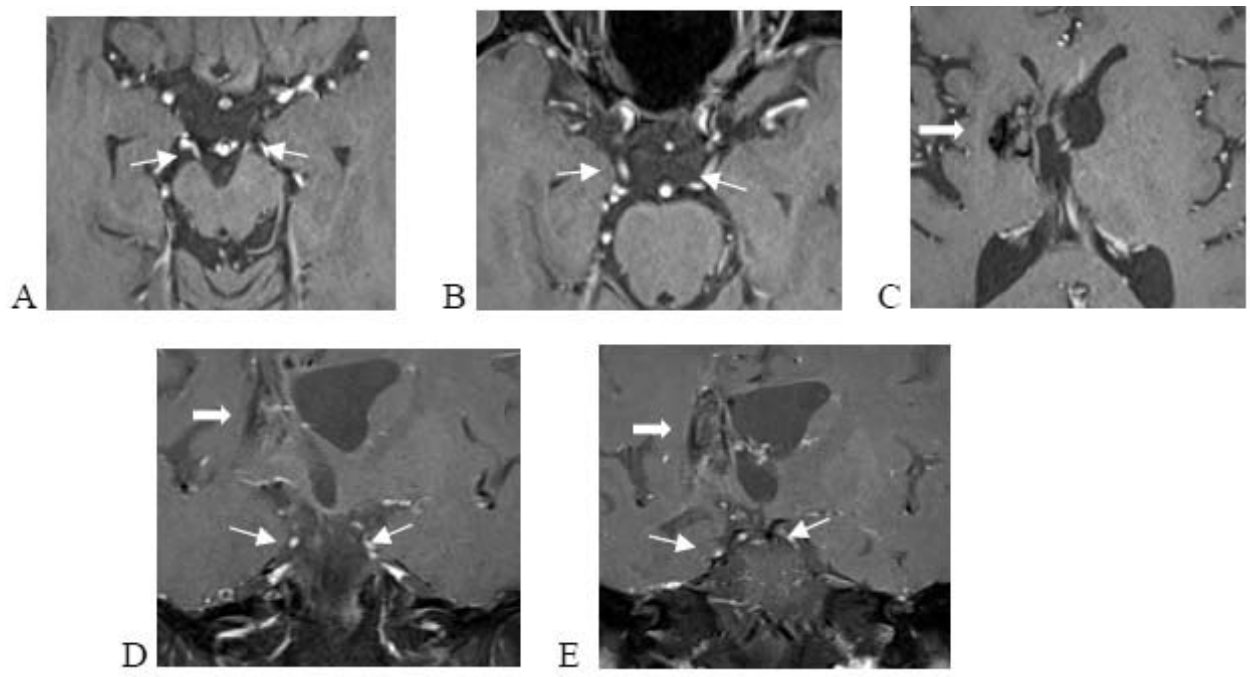

Figure 8. Case 8: Radiation-induced cranial nerve injury: A 33-year-old male, known case of right basal ganglia germinoma underwent surgery and radiation 10 years ago. MRI of the brain axial (A, B, and C) and coronal (D and E) post gadolinium T1WI shows smooth enhancement of cisternal portion of bilateral CN III (A, B, D and E, white arrows). Area of prior tumor involvement in right basal ganglia remained as parenchymal volume loss and hemosiderin deposition (C, D and E, white thick arrow).

Radiation-induced cranial nerve injury is an uncommon, usually delayed, complication of radiation therapy or radiosurgery. CN deficits may be permanent or resolve spontaneously. Loss of the nerve–blood barrier due to demyelination and ischemia, coagulation necrosis, or peripheral fibrosis results in cranial nerve enhancement.[2]

Discussion

MRI is the imaging of choice to evaluate the cranial nerves. Although the skull base foramina can be seen on CT, the nerves themselves can only be visualized in detail on MRI. Detailed clinical information is needed by the radiologist so that a dedicated MR study for CN can be performed. Imaging plane, coil, sequence choice, slice thickness, use of special techniques like parallel imaging, asymmetric k-space, fat suppression, and so will all influence the final image quality.[16]

The choice of the sequence will depend on the tissue or fluid that is surrounding the nerve. In the brain stem, the CN nuclei and fascicular segment of the nerve cannot be visualized but their location can be deduced when the surrounding myelinated structures are recognized. These are best seen on T2WI, proton-density and especially multi-echo fast field echo (m-FFE) or T2"W 2D spoiled gradient echo multiecho sequence (MEDIC) images. Heavily T2W sequences are used once the cisternal segment of the nerve. The sequences that are available or used depend highly on the type of MR unit. Typically CISS, 3D-TSE, b-FFE, DRIVE, 3D-FSE, FIESTA or 3D FSE XETA are used.

Once the nerves are surrounded by a venous plexus (CN III to CN VI in the cavernous sinus, CN VI behind the clivus in the basilar plexus, CN IX to CN XI in the jugular foramen, CN XII in the hypoglossal canal) they are best seen on high resolution contrast enhanced 2D (SE or TSE) or 3D (TSE or FFE) T1W images. On these images, the CNs are seen as black structures surrounded by high signal intensity gadolinium-filled venous structures.

The peripheral segments and branches of the CNs are surrounded by soft tissues and especially fat in the neck and face. High resolution T1W SE and TSE sequences without fat saturation are best suited in this region to visualized the nerves. The use of fat saturation will make the fat disappear and makes

visualization of normal nerves difficult or impossible. Fat saturation has additional value only when an abnormal enhancement of the nerve is expected.[16]

MRI with contrast enhancement is a valuable tool for detecting and characterizing disease of the CN. MR appearance of abnormal CN enhancement in various diseases. Our cases demonstrating inflammatory process, hematologic malignancy, perineural spreading of extracranial tumor, CSF seeding of high grade primary brain tumor, demyelination and post radiation change as cause of abnormal cranial nerve enhancement. Incorporating image findings with clinical information, disease duration, and laboratory investigation may lead to final diagnosis.

Conclusion

Abnormal enhancement of CNs has wide range of probable etiologies, including inflammatory process, hematologic malignancy, perineural spreading of extracranial tumor, CSF seeding of high grade primary brain tumor, demyelination, and post radiation change. The use of contrast enhanced 3D T1WI MRI and appropriate MRI sequences can increase conspicuity of the finding. Incorporating underlying disease, clinical duration, and associated intracranial / extracranial findings may help radiologists narrowing the possible differential diagnosis in each case.

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