Hirayama disease: Three cases

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Abstract Hirayama disease is a rare, lower cervical myelopathy affecting young adults. It is responsible for pure distal motor impairment of the upper limbs, with slow progressive development in the metameric territories of C7 to T1. It is thought to be caused by movements involved in flexing the neck. Neutral position magnetic resonance imaging (MRI) looks for abnormal cervical curvature, atrophy with flattening of the cervical spine, anterior cord hyperintensity and especially a lack of posterior apposition of the dural sac. If the condition is suspected, an MRI in flexion should be performed to show anterior displacement of the cord and dural sac, enlargement of the posterior epidural space, an increase in flattening of the cord and congestion of the epidural veins. These dynamic abnormalities tend to disappear after evolving for 10 years. We report two confirmed cases and a probable case of Hirayama disease and discuss its physiopathology.

Hirayama disease, or juvenile muscular atrophy of the distal upper limb, is a rare condition, most often affecting patients of Asian origin and described for the first time in 1959 by the neurologist K. Hirayama [1]. This disease is characterised by progressive, unilateral or bilateral asymmetric muscle atrophy of the distal extremities of the upper limbs. The motor impairment mainly concerns the muscles of the forearm and hand, and is potentially aggravated by the cold. Characteristically, the brachioradialis muscle, with C6 innervation, is usually spared. We thus talk of ‘oblique’ muscular atrophy. It mainly affects young male adults between 15 and 17 years old, who are often sports players and slender [2].

The electromyogram (EMG) shows neurogenic damage in the C7-C8-T1 territories.

The current physiopathological hypothesis is based on chronic ischaemic damage to the lower cervical cord caused by it being crushed against the vertebral bodies, particularly during cervical flexion movements [3].
**Case presentation**

**Case n° 1**

The first observation concerned a 17-year-old sports player, who consulted for the progressive appearance of weakness of his right hand, aggravated by cold. The clinical examination found motor impairment and muscular atrophy in both hands but more pronounced on the right, overflowing the territory of the ulnar nerve. He had no cranial nerve impairment, pyramidal syndrome or sensory deficit. In the EMG there was bilateral reduction (with a greater predominance on the right) of the distal motor amplitudes of the median and cubital nerves, without conduction abnormalities or sensory impairment. In detection, the C8/T1 territories were clearly neurogenic, pointing towards impairment of the anterior horn of the cervical cord.

An initial cervical MRI in neutral position found the cervical spine to be straight, atrophy with C5-C6 anteroposterior flattening of the cord, and a lack of posterior apposition of the dural sac (Fig. 1).

Given the suspicion of Hirayama disease, an additional MRI was performed in flexion. This showed anterior displacement of the lower cervical cord and dural sac and enlargement of the posterior epidural space (Fig. 2).

**Case n° 2**

The second observation concerned a right-handed, 18-year-old male, with no personal or family medical history. He consulted for the progressive appearance over a few months of weakness in his right hand, with stiffening when cold, but no associated sensory deficit. These symptoms had appeared when he worked regularly with his head in flexion.

On examination, there was interosseous deficit, with atrophy of the first interosseous muscle and the hypothenar muscles, and deficit of the flexor pollicis longus and the deep flexor of the index finger, of the palmar muscles and of pronation.

An EMG showed pure motor neurogenic impairment without any sensory involvement occurring bilaterally but with predominance on the right affecting the C7-C8-T1 territories. Damage to the roots or anterior cervical cord was suspected. Cervical MRI found the cervical spine to be straight, atrophy of the cord, bilateral hyperintensity

![Figure 1](image1.png)  
**Figure 1.** Case n° 1 cervical MRI in neutral position. Sagittal T2-weighted TSE (a), axial T2-weighted GE (b) sequences at C6-C7 in neutral position. The initial MRI shows cervical spine stiffness, C5-C6 atrophy (arrow), posterior detachment of the dural sac (star).

![Figure 2](image2.png)  
**Figure 2.** Case n° 1 cervical MRI in flexion. Sagittal T2-weighted TSE (a), axial T2-weighted GE (b) sequences in flexion. MRI in flexion shows anterior displacement of the spinal cord and dural sac (arrow), flattening of the lower cervical cord and dilatation of the epidural veins (star). The epidural veins are clearly hypointense, due to the flow artefact.
centred on the anterior horns, and a lack of apposition of the posterior dural sac (Fig. 3).

Given a clinical and radiological picture compatible with Hirayama disease, cervical MRI in flexion was also undertaken (Fig. 4). This showed enlargement of the posterior epidural space in flexion combined with anterior displacement of the dural sac and cervical cord. Dilated vascular structures could be seen in the epidural spaces.

**Case nº 3**

The third observation concerned a right-handed 22-year-old male patient, a nurse with no medical history, who consulted after a pure motor deficit had been developing over two years in his right arm, progressively worsening without any sensory deficit or pain. The clinical examination revealed a deficit of the finger extensors and major atrophy of the triceps in the right upper limb.

The initial EMG showed partial denervation of the extensor digitorum and the triceps (C7), with the right brachioradialis (C6) being spared. Sensory and motor nerve conduction was normal.

Cervical MRI showed right anterolateral intramedullary hyperintensity extending from C5 to C6, associated with atrophy of the cord at this level (Fig. 5).

MRI of the brachial plexus was normal.

Hirayama disease was not considered and the aetiological report remained negative.

The picture worsened with scapula alata resulting from clinical involvement of the serratus anterior, with C5, C6 and C7 innervation. After developing for approximately three years, the clinical situation stabilised.

A new EMG six years after the onset of symptoms found right C7 neurogenic impairment. The control cervical MRI showed worsening of the right anterolateral cord atrophy, extending from C4 to C7, with the formation of a syringomyelic fissure in the hyperintense area seen previously.

A diagnosis of Hirayama disease was only belatedly suggested, after approximately thirteen years of development, when another MRI in neutral position then in flexion was performed (Fig. 5).

There was clear lateralised right cord atrophy at the C5-C6 levels and relative lack of apposition of the posterior dural sac. Cervical flexion showed neither enlargement of the posterior epidural spaces nor anterior displacement of the dural sac or the cervical cord.

**Discussion**

Hirayama disease, also called juvenile muscular atrophy of the distal upper limb, is a rare lower cervical myelopathy affecting young adults, responsible for pure motor impairment of the C7 to T1 myotomes aggravated by flexion of the neck [1].

It is characterised by biphasic development, with progressive worsening of symptoms over 3 to 4 years, followed by a phase in which the disease stabilises [1]. The cranial nerves are not affected and there is usually no pyramidal syndrome [1].

Bilateral and symmetrical involvement should not lead to questioning the diagnosis but may be considered as a severe form of Hirayama disease [4].

The EMG shows signs of acute and chronic muscle denervation in the territory of the C7 to T1 metamers. Ninety per cent of patients with unilateral clinical symptoms have
bilateral signs of denervation in the EMG. Nerve conduction speeds are usually normal [5].

MRI typically finds abnormal curvature of the cervical spine (kyphosis or straightness). It is associated with C5-C6 cord atrophy, with anteroposterior flattening of the cord, increased by flexion. Anterior hyperintensity of the cord can sometimes be seen. Finally, posterior apposition of the dural sac to the vertebral laminae is seen to be lacking. This is the most specific sign for confirming Hirayama disease on cervical MRI in neutral position [6].

During flexion, anterior displacement of the lower cervical cord and posterior dural sac is seen, responsible for crushing the cord against the posterior vertebral wall. This is associated with enlargement of the posterior epidural space within which dilated veins appear. The cervical flexion recommended is between 30 and 40 degrees [7]. Flattening of the spinal cord in the flexed position is inversely correlated with the length of time that the disease has been developing and tends to disappear in patients who are more than 30 years old or who have had symptoms for more than ten years [7].

The pathological physiology is still debated. It has been suggested that Hirayama disease is a variant of motor neurone disease. Some studies have reported that there may be electromyographic damage to the muscles of the thoracic wall and lower limbs lending weight to the hypothesis of a degenerative origin [8]. But this has been refuted by autopsy data, which found ischaemic phenomena. Indeed, pathological anatomy studies have revealed moderate gliosis, large and small neurone loss and central medullary necrosis of the lower cervical cord [9].

The pathophysiological hypothesis currently most widely accepted is that there is disproportionate growth of the spine relative to the dural sac [10].

The dural sac is attached to the spine at two fixed points, proximally at the foramen magnum and at C2 and C3, and distally at the coccyx. In a healthy subject, there is a certain laxity allowing it to adapt to flexion movements of the neck. In subjects with the disease, the dural sac is too short compared with the length of the spine. Thus, abnormally stretched in a neutral position, it would be in poor juxtaposition with the posterior vertebral laminae.

Figure 5. Case no 3 MRI. Initial MRI in neutral position. Axial T2-weighted GE at C5-C6 (a) and sagittal T2-weighted TSE (b) sequences. On the initial MRI, there is atrophy at C5-C6 (arrow) with anterior right hyperintensity (arrow) and a lack of apposition of the posterior epidural sac (star). Cervical MRI in neutral position and in flexion after 13 years of development. Axial T2-weighted TSE sequence at C5-C6 in neutral position (c). After 13 years of development, the atrophy has increased.
During flexion, the dural sac would not be loose enough to withstand the strain induced by the lengthening of the cervical spine [11].

The spinal cord would thus be crushed by the dural sac against the posterior wall of the vertebral bodies. This would lead to an increase in intramedullary pressure responsible for local disturbances in the microcirculation of the anterior horns of the anterior cervical cord, the region which is most sensitive to ischaemia [12].

It has been suggested that congestion of the epidural venousplexuses aggravating this increased pressure may play a role.

A combination of three pathophysiological factors is thought to be responsible for this congestion. Anterior displacement of the posterior dural sac would cause negative pressure in the posterior epidural space, causing an increased flow in the posterior venous plexus. Secondly, anterior displacement of the dura mater would compress the anterior epidural venous plexus, resulting in an increased load on the posterior venous plexuses. Finally, the reduction in drainage of the jugular veins during flexion of the neck would impede the return of blood in the epidural veins [13].

For the third patient, MRI in flexion showed no anterior displacement of the cord and dural sac or enlargement of the posterior epidural space. Nevertheless, several arguments support a diagnosis of Hirayama disease — the background, the motor neurogenic deficit and the progressive development followed by a period of stabilisation — which are characteristic of the disease. In addition, the differential diagnoses were successively refuted.

The EMG signs of denervation eliminated myogenic impairment. Injury to a single trunk cannot explain all of the symptoms, since the triceps is innervated by the radial nerve and the serratus anterior muscle by the long thoracic nerve. A brachial plexus injury was eliminated by performing an MRI of the plexus, which was negative. A juvenile form of amyotrophic lateral sclerosis (ALS) was also discussed. The absence of fasciculation, bulbar signs and central nervous injury, and the clinical stabilisation of the disease eliminated this diagnosis. Other causes of anterior cervical cord impairment such as spondylothesis, syringomyelia, or a spinal cord tumour were eliminated by the MRI in neutral position, which found the cardinal signs of the disease, particularly the lack of posterior apposition of the dural sac. The fact that MRI in flexion may show normality does not exclude the diagnosis, as it has been demonstrated that the disease normalises after several years of evolution [3].

Hirayama disease is rare and probably under-diagnosed. If the disease is brought to light late in its course, the diagnosis can only be made based on the clinical picture and neutral position MRI.

Wearing a rigid cervical collar significantly slows progression of the disease [14].

An alternative has been proposed of surgical decompression, with encouraging results [15].

Early recognition of this disease is important, given the existence of effective preventive measures [16].

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References