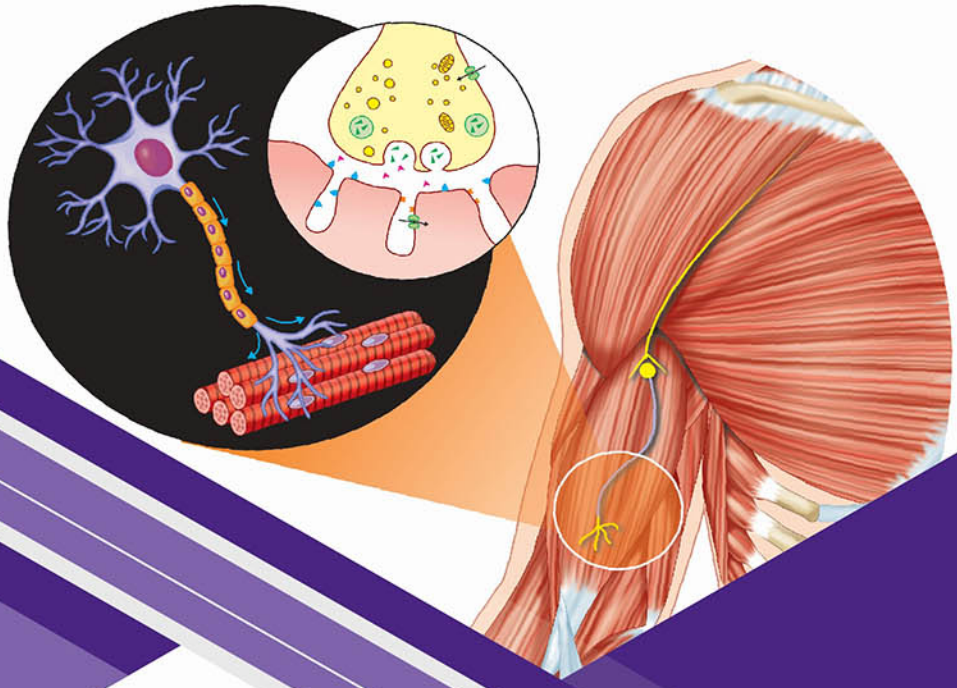
ebrothers.com, for detailed information on neurology books, visit our website www.jaypeebrothers.com, for detailed information on neurology books



Indian Academy of Neurology

Advances in Neuromuscular Disorders

Editor-in-Chief
Debashish Chowdhury

Editors
Atchayaram Nalini
Vishnu VY

JAYPEE

Contents

CHAPTER 1: **Disease-modifying Therapies in Spinal Muscular Atrophy and Duchenne Muscular Dystrophy: A Rapidly Changing Scenario** 1
Ann Agnes Mathew

CHAPTER 2: **Refractory Myasthenia: Management Strategies** 10
Deepak Menon, Seena Vengalil, Saraswati Nashi, Atchayaram Nalini

CHAPTER 3: **Congenital Myasthenic Syndromes: Genetic Spectrum and Management** 20
Seena Vengalil, Samim MM, Saraswati Nashi, Deepak Menon, Atchayaram Nalini

CHAPTER 4: **Idiopathic Inflammatory Myopathies and Current Immunology** 33
Sruthi S Nair, Deepti Narasimhaiah

CHAPTER 5: **Updates on Limb–girdle Dystrophies and Gene Therapies** 52
Vaibhav Wadwekar, Abhijeet K Kohat, Ragavendar Bhuvaneswaran

CHAPTER 6: **Clinical Utility and Interpretation of Genetic Testing in Neuromuscular Disorders** 64
Ajith Sivadasan, Karthik Muthusamy, Aditya Nair

CHAPTER 7: **Facioscapulohumeral Dystrophy: Update on Treatment** 80
Alisha Reyaz, Vishnu VY

CHAPTER 8: **Riboflavinopathies: Potentially Treatable Disorders** 93
Saraswati Nashi, Seena Vengalil, Dipti Baskar, Deepak Menon, Atchayaram Nalini

CHAPTER 9: **Mitochondrial Disorders: A Neuromuscular Perspective** 103
Madhu Nagappa

CHAPTER 10: **Therapeutic Advances in Nodoparanodopathies** 113
Satish Khadilkar, Varsha Patil, Jharna Mahajan

CHAPTER 11: **Chronic Inflammatory Demyelinating Polyradiculoneuropathy and its "Variants": Current Treatment Recommendations** 124
Rakesh K Singh, Anuradha Mahto

CHAPTER 12: **Neuromuscular Imaging: MRI and Ultrasound** 136
Lokesh Bathala, Y Muralidhar Reddy

CHAPTER 13: **Hirayama Disease/Monomelic Amyotrophy: Recent Advances and Surgical Management** 152
Atchayaram Nalini, Dipti Baskar, Nupur Pruthi, Dhananjay Bhat, Seena Vengalil

CHAPTER 14: **Recent Classification and Emerging Therapies in Charcot–Marie–Tooth Disease** 167
Ritu Shree, Manoj Kumar Goyal

CHAPTER 15: **Genetics of Amyotrophic Lateral Sclerosis and Implications for Therapy** 178
Saranya B Gomathy, Seena Vengalil, Atchayaram Nalini

Index 191

CHAPTER 13

Hirayama Disease/Monomelic Amyotrophy: Recent Advances and Surgical Management

Atchayaram Nalini, Dipti Baskar, Nupur Pruthi, Dhananjay Bhat, Seena Vengalil

ABSTRACT

Hirayama disease (HD) or monomelic amyotrophy affects young males and is a cervical flexion-induced myelopathy (CFIM) characterized by progressive unilateral or more commonly bilateral asymmetrical/symmetrical weakness and atrophy of distal forearm and hand muscles. Magnetic resonance imaging demonstrates classical forward displacement of posterior dura in the lower cervicothoracic cord on neck flexion resulting in ischemic-atrophy of the anterior horn cells and other tracts in the region. Currently surgical intervention is the choice of treatment for patients diagnosed in the early progressive phase of the illness. The damage and disability can be stalled or reversed by cervical decompressive surgeries.

Keywords: Hirayama disease, Cervical flexion-induced myelopathy, Monomelic amyotrophy, Bimelic amyotrophy, Proximal bimelic amyotrophy.

INTRODUCTION

Hirayama disease (HD) is a cervical flexion-induced myelopathy (CFIM) and predominantly affects young Asian males and is characterized by progressive unilateral or more commonly bilateral asymmetrical weakness and atrophy of distal forearm and hand muscles without clinical sensory disturbance or lower limb involvement.[1,2] Since its initial description by Dr Keizo Hirayama and colleagues in 1959, it is described by various namessuch as juvenile nonprogressive monomelic amyotrophy (JNPMA), juvenile asymmetric segmental spinal muscular atrophy (JASSMA), juvenile muscular atrophy of the distal upper extremity (JMADUE), benign juvenile brachial spinal muscular atrophy (SMA), oblique atrophy, benign focal amyotrophy, and monomelic amyotrophy. The disease has a progressive course with possible spontaneous arrest after several years but resulting in significant disability in the majority. Therefore, early recognition and intervention is imperative to prevent progression and functional impairment. With the advent of magnetic resonance imaging (MRI) in 1980s, it is shown that HD patients demonstrate characteristic forward displacement of posterior dura in the lower cervicothoracic cord on neck flexion resulting in ischemicatrophy of the anterior horn cells (AHCs) in the region. Currently surgical intervention is the choice of treatment for

JAYPEE BROTHERS

patients diagnosed in the early phase of the illness. This damage can be stalled or reversed by cervical decompressive surgeries.

EPIDEMIOLOGY

The majority of cases of HD are from Asia with only a few reports from other countries such as Europe, Australia, and North America.[3-5] The disease has striking male predominance with male to female ratios of 8.3:1 and 20:1 in Japan; 11:1 and 31.6:1 in China; and in India ratio ranges from 9:1 to only males.[6-9] In the nationwide epidemiological survey in Japan done by Tashiro and colleagues, the male preponderance was speculated to be due to rapid height gain as compared to females at puberty.[6] The onset of symptoms is mainly in the late second or early third decade ranging from 15 to 20 years in various cohorts.[6,8] The age of onset peaks around pubertal growth spurt which is attributed to disproportionate growth of vertebral column and spinal canal contents, especially the dural sac. Though initially HD was considered a sporadic disease, there are reports of familial clustering with two candidate genes identified, *KIAA1377* [also known as centrosomal protein 126 (CEP 126)] and chromosome 5 open reading frame 42 (*C5orf42*) and suggested as susceptibility genes to develop HD.[10] The basis for familial occurrence and genetic factors that affect growth and development of vertebral column and contents are yet to be elucidated.

Etiopathogenesis

The central pathogenesis of dynamic cord compression has been postulated and hypothesized by various theories such as dural sac theory, nerve root theory, dural structural abnormality, abnormal venous engorgement, immunological theory, and incongruous strength of cervical spine muscle with weak superficial extensors than flexors contributing to spine instability. However, venous stasis-ischemia hypothesis is the most plausible explanation for the occurrence of HD and can lead to venous congestive myelopathy due to venous stasis and ischemia.[11]

CLINICAL FEATURES

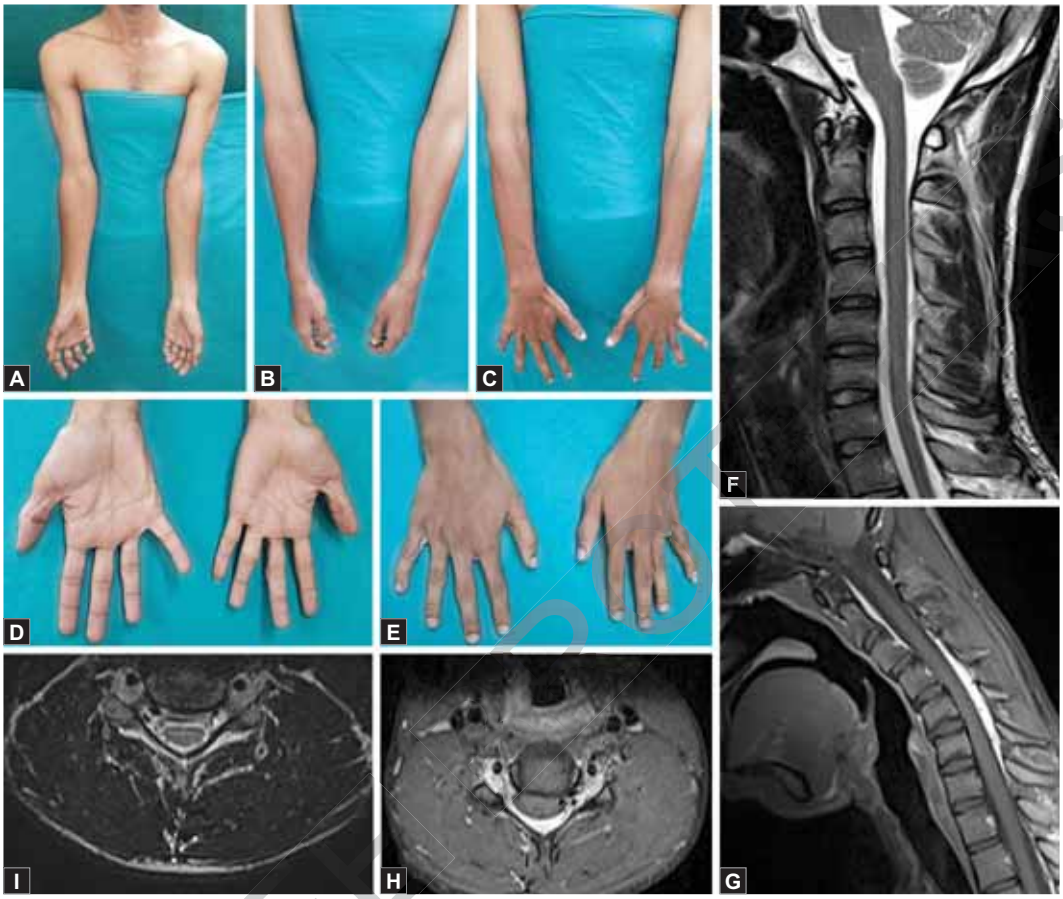
The typical HD, also known as brachial monomelic amyotrophy (BMMA) has the following clinical features **(Figs. 1A to I)**:

- Insidious onset with progression initially for 3–5 years followed by arrest. The motor disability is variable from mild to severe.
- Unilateral or asymmetrical bilateral wasting and weakness of the distal upper limbs (ULs), with predominant wasting of the ulnar aspect of the hand resulting in characteristic "reverse split hand syndrome" in contrast to "split hand" noted in amyotrophic lateral sclerosis (ALS) with thenar wasting. This is hypothesized due to hypothenar AHC susceptibility in HD compared to thenar AHC susceptibility to apoptosis in ALS. There is also characteristic sparing of brachioradialis muscle in the forearm resulting in "oblique atrophy".
- Coarse irregular tremors called mini-polymyoclonus of the affected hands.
- Cold paresis, noted in 97% of HD patients. Previous study on axonal excitability on cold exposure has shown increased refractoriness of sodium channels on immature sprouting neurons.[12]
- Absence of objective sensory disturbance.

VARIANTS OF HIRAYAMA DISEASE

In addition to the typical clinical features of HD described earlier, there are various atypical features which have to be borne in mind during diagnosis.

JAYPEE BROTHERS



FIGS. 1A TO I: Clinical and MRI images of typical brachial monomelic amyotrophy (BMMA). (A to C) Oblique atrophy of forearm with sparing of brachioradialis; (D and E) Hypothenar wasting noted in right hand (reverse split hand); (F) T2-weighted (T2W) showing loss of cervical lordosis. (G) T1 postcontrast shows posterior crescentic enhancement; (H) T1-weighted (T1W); and (I) T2W—flattening and asymmetric cord atrophy.

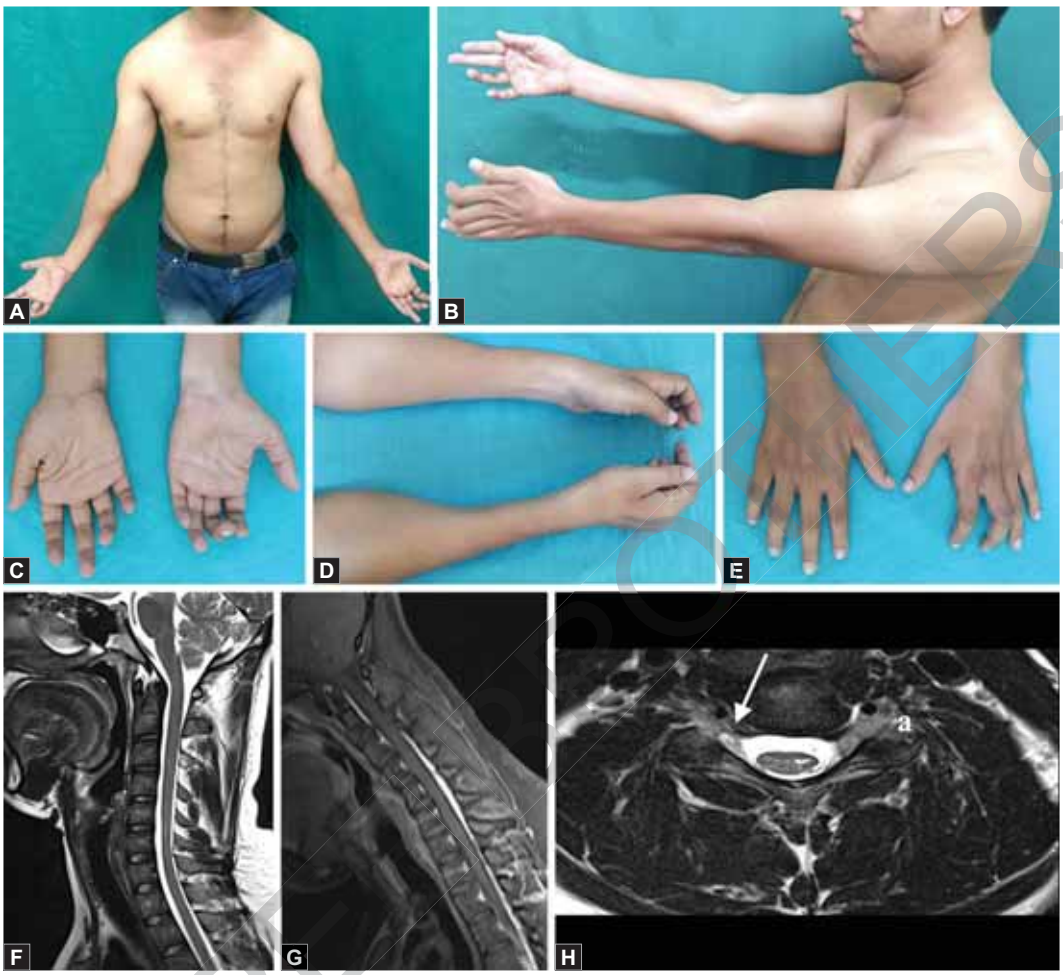
Distal Bimelic Amyotrophy (Figs. 2A to H)

Classical HD/BMMA is primarily unilateral even though with later involvement of the contralateral UL, it grossly remains asymmetrical. In distal bimelic amyotrophy (DBMA), there is symmetrical bilateral severe distal UL involvement with affection of C7-T1 AHCs. However, DBMA carries all other typical features of HD/BMMA such as onset in early 20s, arrest after initial progression for 2–3 years, significant disability, and dynamic cervical MRI features.[13]

Crural Monomelic Amyotrophy (Figs. 3A to D)

Similar to classical brachial variant, crural phenotype causes muscle atrophy and

JAYPEE BOOKS



FIGS. 2A TO H: Clinical and MRI images of distal bimelic amyotrophy (DBMA). (A to E) Symmetrical forearm atrophy with brachioradialis sparing and hypothenar wasting. (F) T2-weighted (T2W)—cord atrophy from C6 to T1; (G) T1-weighted (T1W) postcontrast—posterior crescentic enhancement; and (H) (T2W)—cord flattening with anterior horn enhancement.

JAYPEE BROTHERS

weakness involving unilateral or asymmetrical bilateral lower limbs[8] although MRI features are not detectable.

Upper Motor Neuron Involvement

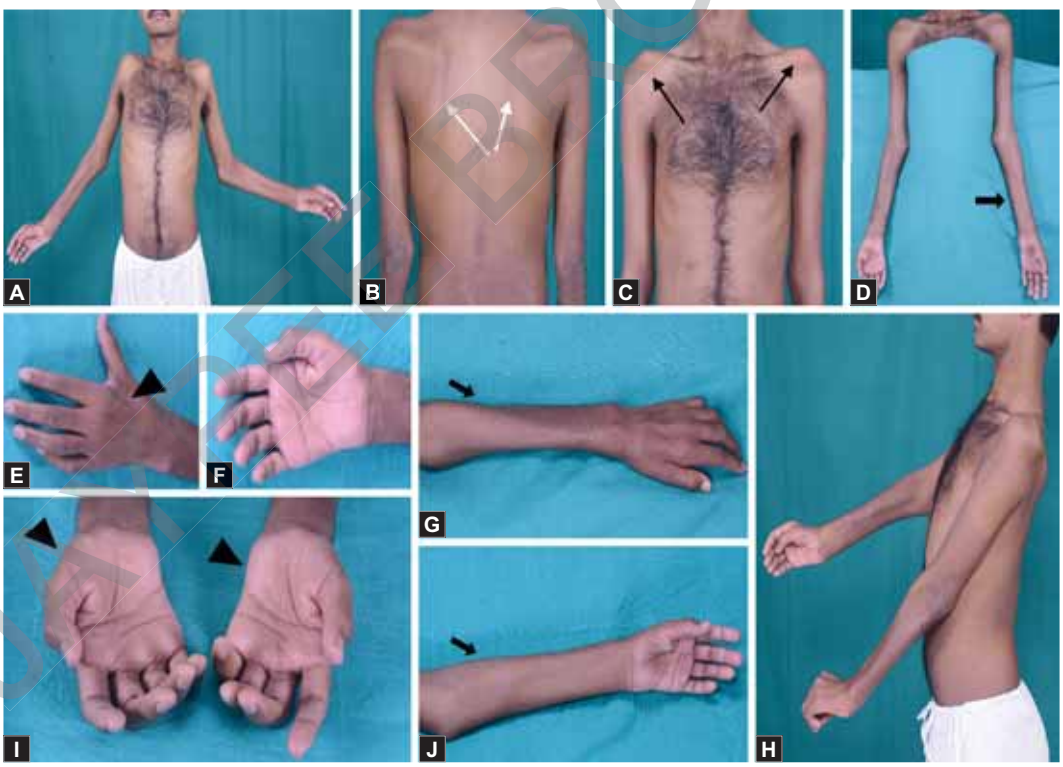
Severe cord involvement in HD can result in hyperreflexia and inverted tendon reflexes, especially of lower limbs. Previous studies have reported pyramidal involvement in HD ranging from 2.4 to 18%.[6,14,15]

Proximal Variant (Figs. 4A to J)

Proximal bimelic amyotrophy (PBMA) and proximo-distal bimelic amyotrophy (PDBMA) are uncommon variants with wasting and weakness of shoulder girdle muscles.[7] They can be unilateral or bilaterally asymmetrical and have severe motor disability similar to DBMA. Compared to BMMA and DBMA, proximal variants have higher cervical level compression at C4–C5 levels.[13,16]



FIGS. 3A TO D: Clinical images of Crural monomelic amyotrophy (MMA). (A to C) Left upper limb progressive distal wasting and weakness with cold paresis; and (D) Left lower limb wasting.



FIGS. 4A TO J: Clinical images of proximal variant of Hirayama disease (HD). (A and H) Severe weakness of shoulder girdle muscles; (B) Bilateral scapular prominence; (C) Bilateral deltoid wasting; (D) Bilateral forearm wasting; (E, F, and I) Hypothenar and thenar wasting; and (G and J) Brachioradialis sparing.

JAYPEE BROTHERS

DIAGNOSIS

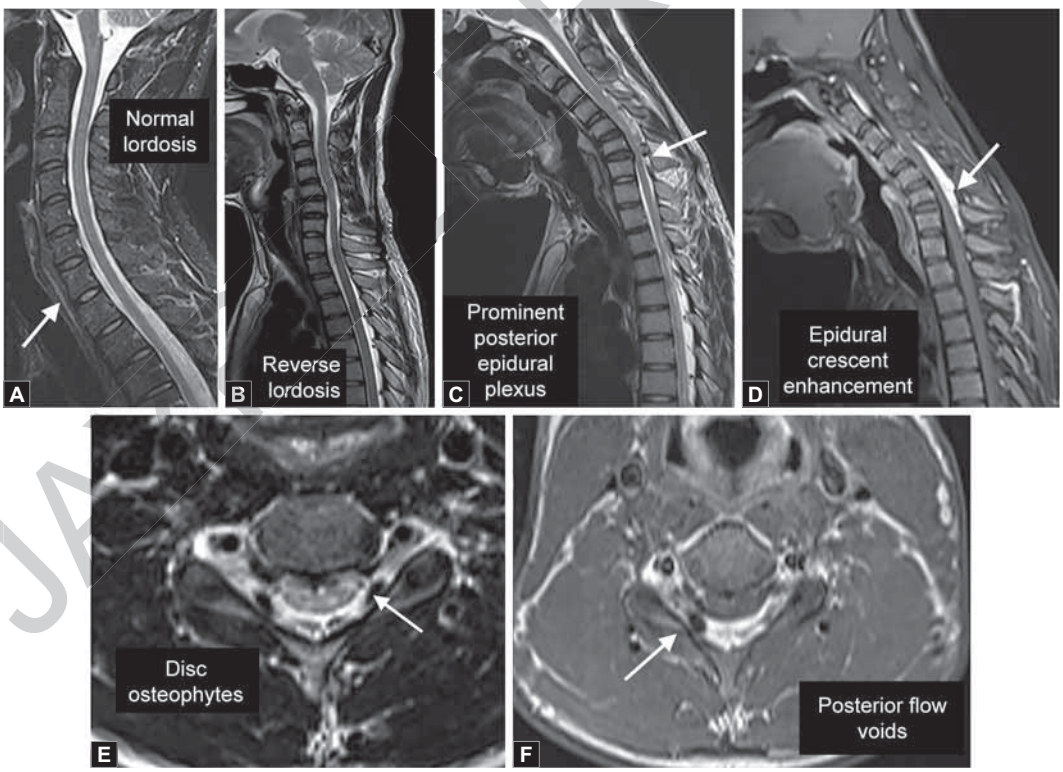
Diagnosis of HD relies on classical and nonclassical manifestations and characteristic observations on spine MRI.

Imaging Features

Imaging studies play an important role in diagnosis of HD. MRI cervical spine plays a pivotal role in diagnosis of HD. The optimal MRI requirements include 1.5T to 3.0T scanner with sequence protocol of sagittal and axial T1-weighted and T2-weighted (T2W) fast/turbo spin echo and T1-weighted fat saturation before and after gadolinium contrast administration and a slice thickness of ideally 3–4 mm.[17] The MRI should be acquired in both neutral and neck flexed position of angle 35–40° preferably in prone position (unpublished data/personal experience).[18] The main findings in MRI can be broadly classified into those obtained in neutral and flexed positions, though flexed neck findings are more sensitive and specific to HD **(Figs. 5 and 6)**.

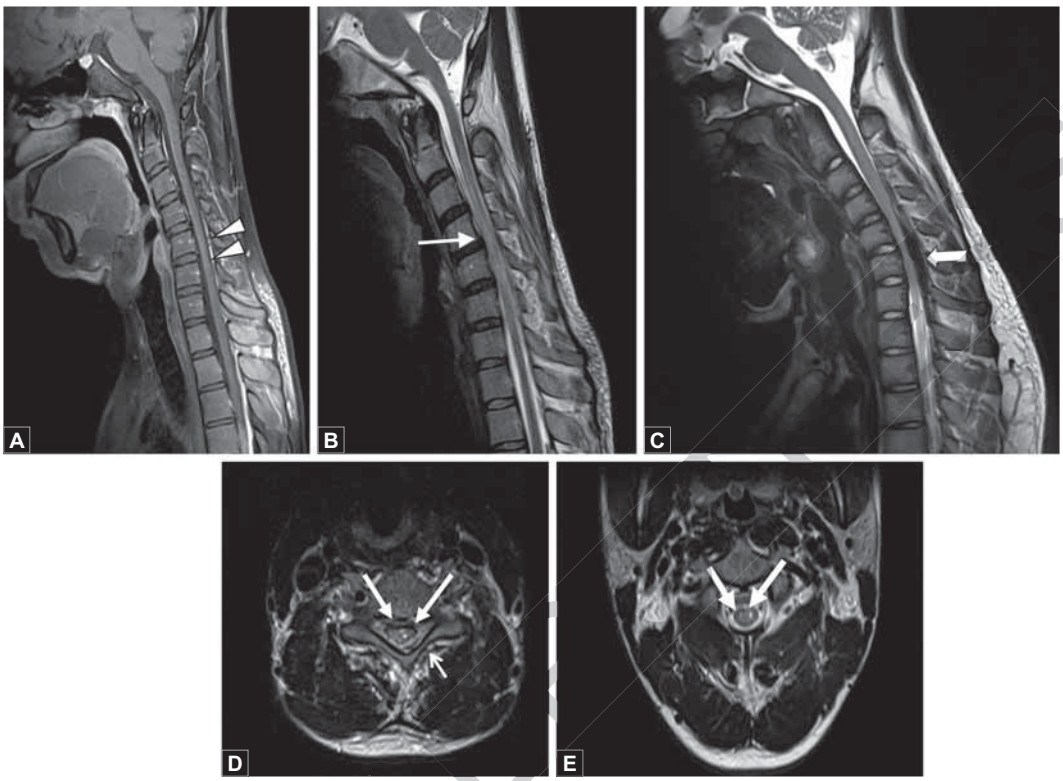
Neutral position findings include:

- Loss of normal cervical lordosis. In case of proximal variants of HD, the degree of kyphosis is more, especially at C3–C4 and C4–C5 levels while the lower part of cervical spine has retained lordosis resulting in "reverse S" appearance.[19]
- Cord atrophy mostly at C5–C7 levels. Reports of focal cord atrophy resulting in "sand watch" appearance in sagittal view.[20]



FIGS. 5A TO F: Salient MRI features of Hirayama disease (HD).

JAYPEE BROTHERS



FIGS. 6A TO E: MRI features of Hirayama disease (HD). (A) Postcontrast fat saturation T1-weighted (T1W) in flexion showing epidural soft tissue enhancing (white arrow heads); (B) T2W in flexion showing altered signal intensity (white arrow); (C) T2-weighted (T2W) in flexion showing hypointense epidural tissue with flow voids pushing the cord forward (white arrow); and (D and E) T2W images at the level of C2 and C6 asymmetric gliosis of anterior horn cells.

- Asymmetrical cord flattening in axial images. Cord flattening and atrophy denotes severe cord involvement and poor recovery following surgery.[3,21,22]
- T2 hyperintensity of anterior horns giving the characteristic "snake eye" or "owl's eye" appearance, seen in around 17–77% in HD **(Fig. 7)**.[17,23,24]
- Loss of attachment of posterior dura to the underlying lamina, considered to the most important sign in neutral position with sensitivity and specificity of 93% and 98%, respectively.[25] Loss of attachment is more extensive in proximal group with progression of disease reflecting more severe disease phenotype.[26]

Flexed cervical MRI reveals pathognomonic imaging features as following:

- Anterior displacement of posterior dural sac, the degree of displacement is 6–9 mm as compared to 1–4 mm seen in normal subjects. MRI based spinal ratio between maximum forward displacement of posterior dura and spinal canal diameter is increased in flexed position resulting in significant cord flattening.[27]
- Widening of posterior laminodural space.
- Prominent epidural flow voids seen as T2W hypointense linear structures due to engorgement of posterior epidural venous plexus.

JAYPEE

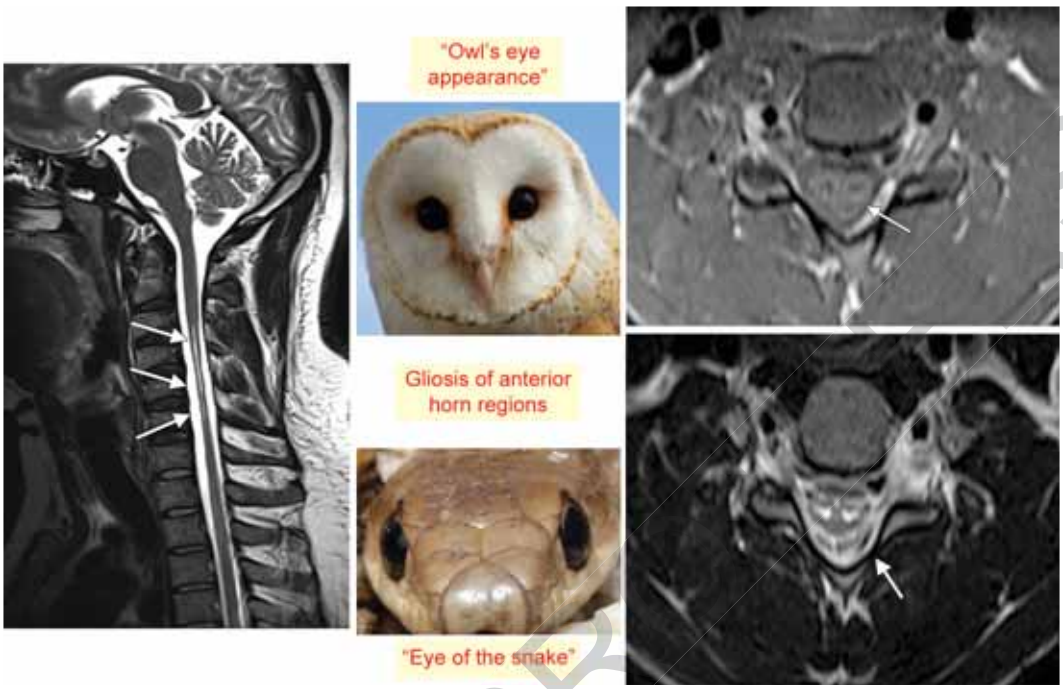


FIG. 7: MRI spine—"snake's eye/owl's eye" appearance.

- Postcontrast enhancement of posterior epidural plexus seen as "crescent-shaped" structure.[14] The enhancement typically disappears on return to neutral position.

The combination of MRI findings on neutral and flexion position has high sensitivity and specificity of 71% and 100%, respectively.[24]

The major shortcoming of conventional dynamic MRI is lack of correlation between degree of cord compression and symptoms and can be partially overcome by diffusion tensor imaging (DTI). The major findings include reduced functional anisotropy and increased apparent diffusion coefficient (ADC) in flexion imaging.[28] These are useful in early stages of HD and to localize level of maximal cord involvement which can guide surgical decisions.

Electrophysiological Features

The major utility of electrodiagnostic studies is to rule out mimics of HD. The electroneuromyography findings reflect segmental neurogenic dysfunction of AHCs of lower cervical cord without sensory involvement.

Evoked potentials can also have changes in HD with sensory evoked potentials (SEPs) being normal or show changes in N9–N13 and N13–N20 interpeak latencies. Motor evoked potentials (MEPs) show changes during neck flexion such as reduced amplitude, longer central motor conduction time, and prolonged latency.[29]

Diagnostic Criteria

Previous criteria relied solely on the clinical features for diagnosis of HD which resulted in misdiagnosis. Hence, updated criteria known as Huashan diagnostic criteria incorporating

JAYPEE BROTHERS

TABLE 1: Huashan diagnostic criteria.

Elements for diagnosis	Clinical manifestations	Imaging manifestations	Electrophysiological features
Elements for definite diagnos is	1. Occult onset during puberty, more common in males 2. Localized muscular atrophy and weakness of the upper extremities, predominantly in the ulnar forearms and the intrinsic muscles of the hands unilaterally or mainly on one side 3. Absence of cranial nerve involvement and muscular atrophy in other parts of the body such as the lower limbs	1. Atrophy or thinning of the middle and lower cervical spinal cord on either neutral or flexion MRI 2. LOA or the presence of a crescent-shaped high-intensity mass at the posterior epidural space on T2WI	1. Neurogenic lesions located in anterior horns and/or roots of the middle and lower cervical spinal cord 2. Normal or only mild abnormal conduction velocity in peripheral nerves of the upper limbs 3. Absence of obvious involvement of the cranial nerves and thoracic, lumbar or sacral spinal cord as the third point under electrophysiological features
Other elements	4. Cold paralysis and tremors in fingers when they are stretched 5. Active deep tendon reflex and/or positive pathological signs in parts of patients 6. Mild sensory deficits in the upper limbs in a small number of patients	3. Anterior displacement and flattening of the lower cervical spinal cord and narrowing or absence of the anterior spinal space on neck flexion MRI 4. High-intensity signs located in the anterior horn areas on T2WI in parts of patients	
Definite HD*	Meeting criterion 1, 2, and 3	Meeting criterion 1 and 2	Meeting criterion 1, 2, and 3
Probable HD**	Meeting criterion 2 and 3		Meeting criterion 3

*Definite HD means meeting criterion above, with or without other elements.
**Probable HD means meeting criterion above and lack of 1–5 other elements for definite diagnosis, with or without other elements.
(HD: Hirayama disease; T2WI: T2-weighted imaging; LOA: loss of attachment)

clinical features such as duration of disease, subtle pyramidal and sensory signs, neck flexion MRI, and electrophysiology to increase the sensitivity of diagnosis has been described in **Table 1**.[7]

DIFFERENTIAL DIAGNOSIS

The major mimics of HD are conditions which result in muscular atrophy of distal UL muscles and can be classified as follows:

- *Cord lesion*: Cervical spondylotic myelopathy/amyotrophy (CSA), syringomyelia, intramedullary neoplasm, and ossification of posterior longitudinal ligament of cervical spine.
- *Motor neuron disorders*: Early-onset ALS, distal SMA, and flail arm variant of ALS.
- *Neuropathies*: Nerve compression syndromes (carpal tunnel syndrome and thoracic outlet syndrome) and hereditary neuropathies.

JAYPEE BROTHERS

None of the mimics will have the classical MRI findings.

MANAGEMENT

Even though HD is traditionally defined as a self-limiting AHC disease, early detection and treatment are crucial since the condition assumes a stationary phase after significant irreversible motor deficits have occurred. For HD, there are no clear-cut accepted treatment recommendations.

Conservative Management

The cervical collar is the most often used initial treatment because it restricts neck flexion and the ensuing progression. Nevertheless, there are a number of drawbacks to using a collar, including low compliance as it has to be worn constantly for at least 3–4.[30] This could be difficult in tropical countries with warm weather. Moreover, cervical collar has predominantly subjective improvement.

Surgical Management

Various surgical procedures are based on the proposed theories in the pathogenesis of HD. Surgical intervention has become the treatment of choice and possible standard of care in recent times.

The major indications for surgery[31] are:

- Progressive course of illness
- Affliction of homologous limb/lower limb(s)
- Noncompliance to cervical collar therapy
- Compressive cord changes in MRI
- Presence of pyramidal signs

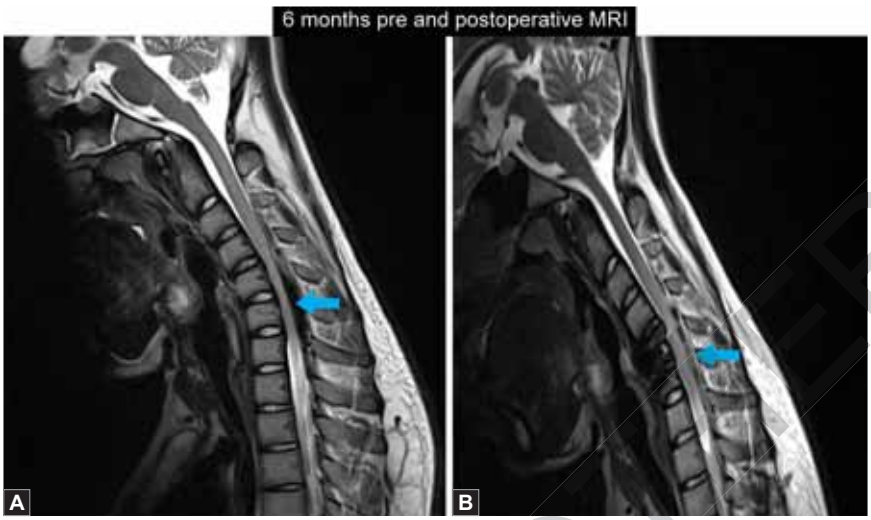
The surgical approaches can be classified into anterior and posterior which can further be subclassified into various procedures such as laminectomy, duraplasty, corpectomy, discectomy, decompression, and fusion.[7,32,33]

The various anterior approaches include:

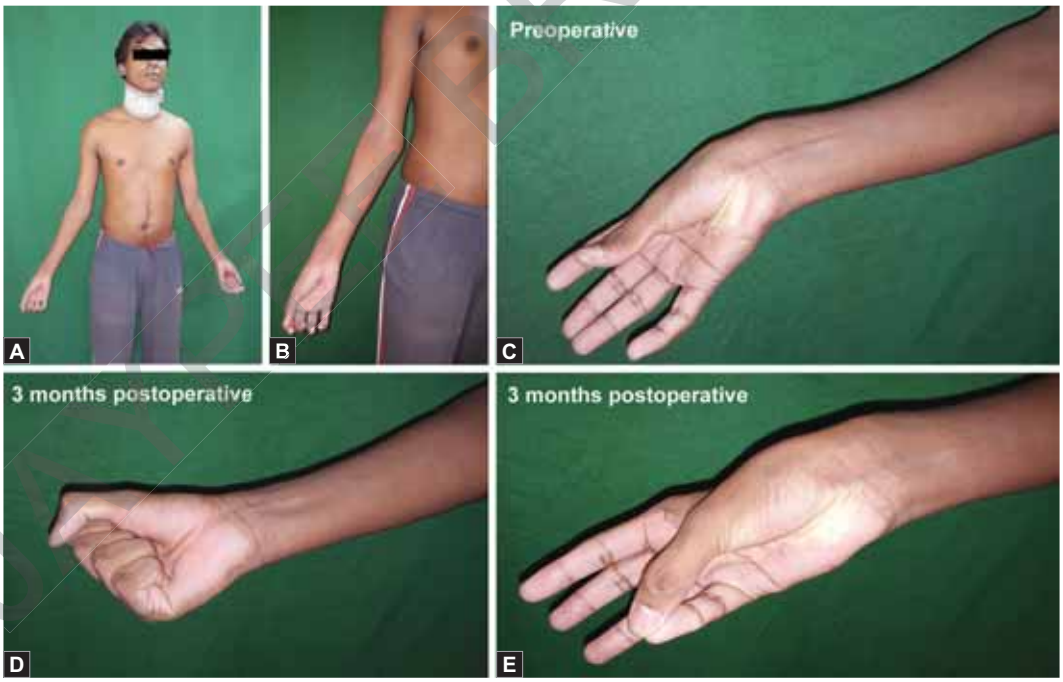
- Anterior cervical corpectomy and discectomy with plate followed by iliac bone graft placement.
- Anterior cervical plating only—consists of fixation of adjacent vertebral segments at the level of spinal cord compression and plating without decompression to restrict movement. There are merits such as ability to remove the plate after stabilization of progression and immobilization of lower cervical spine in lordosis. However, spinal fusion will be required for patients with kyphotic spine alignment or herniated cervical disc with cord compression.
- Anterior cervical discectomy and fusion (ACDF) with or without plating. ACDF with plating has become the most preferred procedure.

The choice of surgical technique is often debated, and it has not been established as to which method is better than the other. Previous pooled analysis has shown a clinical improvement rate of 80% (n = 489) with anterior approaches and 81% (n = 29) with posterior approaches. Anterior techniques such as ACDF and corpectomy are preferred when there is compression in the ventral aspect of thecal sac. Other merits of anterior approach as compared to posterior include prevention of excessive flexion by post discectomy/corpectomy fixation, less pooled blood loss, and significantly less operative time.[34] There were two kinds of ACDF procedures performed: Single level or two-level ACDF. Single level ACDF is preferred as two-level procedures used longer constructs because of the long level compression seen in T2W sagittal images obtained during flexion **(Figs. 8 and 9)**. However, doing a long construct for a more focal disorder is not ideal. The fulcrum of movement of subaxial cervical spine can be checked on flexion

JAYPEE BROTHERS

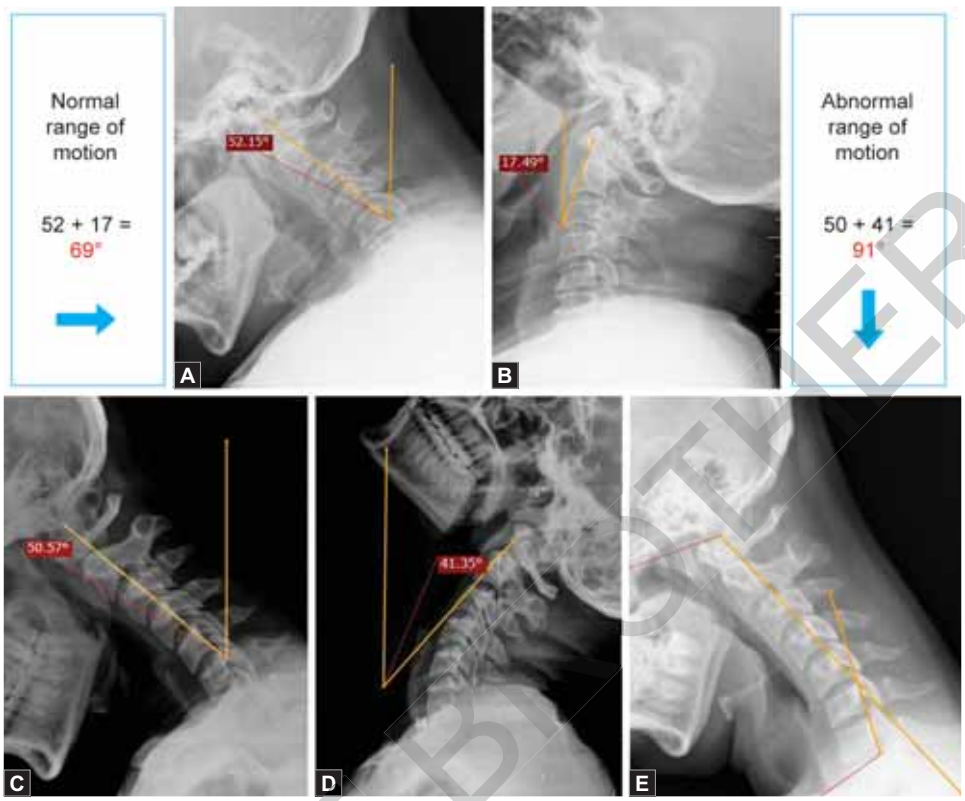


FIGS. 8A AND B: Pre- and postoperative MRI images showing significant reduction in posterior epidural tissue and cord compression.



FIGS. 9A TO E: Clinical images showing postoperative motor improvement of distal upper limbs following anterior cervical discectomy and fusion (ACDF).

JAYPEE BROTHERS



FIGS. 10A TO E: X-ray of cervical spine in flexion showing normal and abnormal range of neck flexion. Level of surgery determined by using the intersection level of two lines drawn along posterior aspect of C2 vertebrae and along posterior aspect of C7 vertebrae.

X-rays of the cervical spine **(Figs. 10A to E)**. This level also corresponds to the maximum level of compression seen on T2W sagittal images acquired during maximum flexion. Thus, single level surgery at this level is considered to minimize the compression in flexion for HD patients.[9] The only advantage with posterior approach is fixation of cervical spine without direct decompression. However, there are several demerits such as risk of excessive bleeding, cerebrospinal fluid (CSF) leakage with risk of meningitis and long operative time.

Comparisons of surgical outcomes of various studies are shown in **Table 2**.

Thus, overall anterior approach is favored over the posterior procedures. The major factors influencing outcome in HD patients include age at onset, duration of symptoms, pathological reflexes, and preoperative motor assessment scores.[9,35]

PROGNOSIS

Most of the HD patients are given benign prognosis with arrest of disease after progressing for 3–5 years. The major morbidity lies in the motor disability of the ULs. The immobilization with cervical collar is shown to be effective in 57.2% of cases.[15] Whereas with surgical invention in properly selected, it was seen to be effective in 46.3–87.6% patients, differing with anterior and posterior techniques.[34] Depending on the stage of intervention, some patients may have residual deficits such as amyotrophy and

JAYPEE BROTHERS

TABLE 2: Comparison with relevant previous studies on surgical outcome in MMA/HD.

Study	Type of study	Total number of patients	Number of patient underwent surgery	Clinical outcome (% of operated patients with improvement)
Anterior corpectomy and cervical plating				
Lu et al., 2013[37]	Prospective	48	24	66.7
ACDF with anterior cervical plating				
Lu et al., 2013[37]	Prospective	48	24 (two level ACDF)	62.7
Guo et al., 2014[38]	Retrospective	4	4 (multilevel ACDF)	100
Song et al., 2017[35]	Retrospective	194	194 (one level ACDF)	87.6
Zou et al., 2019[22]	Retrospective	40	40 (two level ACDF)	60.4
Vengalil S et al., 2024[9]	Retrospective	136	136 (ACDF at single two and multilevel)	84%
Posterior laminectomy with duraplasty				
Lin et al., 2010[39]	Retrospective	6	1	0
Posterior laminectomy and venous plexus coagulation				
Brandicourt et al., 2018[32]	Retrospective	3	3	100
Posterior laminoplasty and duraplasty				
Fujimoto et al., 2002[34]	Retrospective	23	3	100

(ACDF: anterior cervical discectomy and fusion; HD: Hirayama disease; MMA: monomelic amyotrophy)

cold paresis. Rarely, some patients may have progression following a period of stability[36] and if it continues surgical intervention can be considered.[9]

CONCLUSION

Hirayama disease/monomelic amyotrophy is a flexion induced cervical compressive myelopathy resulting in progressive weakness and atrophy predominantly of distal ULs. Contrast-enhanced dynamic flexion cervical MRI is the main imaging modality for prompt and confirmatory diagnosis of this condition. Treatment of HD aims at preventing neck flexion. Surgical decompression should be considered as the first line and mainstay of management rather than considering conservative treatment with use of cervical collarowing to irreversible deficits as the disease progresses. Surgical outcomes as projected in various studies have shown promising benefit and also reversal of symptoms and signs and objective improvement in the motor disability.

REFERENCES

1. Polavarapu K, Preethish-Kumar V, Nashi S, Vengalil S, Prasad C, Bhattacharya K, et al. Intrafamilial phenotypic variations in familial cases of cervical flexion induced myelopathy/Hirayama disease. Amyotroph Lateral Scler Frontotemporal Degener. 2018;19:38-49.
2. Preethish-Kumar V, Polavarapu K, Singh RJ, Vengalil S, Prasad C, Verma A, et al. Proximal and proximo-distal bimelic amyotrophy: Evidence of cervical flexion induced myelopathy. Amyotroph Lateral Scler Frontotemporal Degener. 2016;17 (7-8):499-507.

JAYPEE BROTHERS

3. Vitale V, Caranci F, Pisciotta C, Manganelli F, Briganti F, Santoro L, et al. Hirayama's disease: an Italian single center experience and review of the literature. Quant Imaging Med Surg. 2016;6(4):364-73.
4. Ghosh PS, Moodley M, Friedman NR, Rothner AD, Ghosh D. Hirayama disease in children from North America. J Child Neurol. 2011;26(12):1542-7.
5. Kusel K, Warne R, Lakshmanan R, Mason M, Bynevelt M, Shah S. Hirayama disease: the importance of flexion imaging. BJR Case Rep. 2021;8(1):20210105.
6. Tashiro K, Kikuchi S, Itoyama Y, Tokumaru Y, Sobue G, Mukai E, et al. Nationwide survey of juvenile muscular atrophy of distal upper extremity (Hirayama disease) in Japan. Amyotroph Lateral Scler. 2006;7(1):38-45.
7. Wang H, Tian Y, Wu J, Luo S, Zheng C, Sun C, et al. Update on the Pathogenesis, Clinical Diagnosis, and Treatment of Hirayama Disease. Front Neurol. 2022;12:811943.
8. Nalini A, Gourie-Devi M, Thennarasu K, Ramalingaiah AH. Monomelic amyotrophy: clinical profile and natural history of 279 cases seen over 35 years (1976-2010). Amyotroph Lateral Scler Frontotemporal Degener. 2014;15(5-6):457-65.
9. Vengalil S, Pruthi N, Bhat D, Uppar AM, Polavarapu K, Preethish-Kumar V, et al. Monomelic Amyotrophy/Hirayama Disease: Surgical Outcome in a Large Cohort of Indian Patients. World Neurosurg. 2024;183:e88-97.
10. Lim YM, Koh I, Park YM, Kim JJ, Kim DS, Kim HJ, et al. Exome sequencing identifies KIAA1377 and C5orf42 as susceptibility genes for monomelic amyotrophy. Neuromuscul Disord. 2012;22(5):394-400.
11. Foster E, Tsang BK, Kam A, Stark RJ. Mechanisms of upper limb amyotrophy in spinal disorders. J Clinical Neurosci. 2014;21:1209-14.
12. Sawai S, Misawa S, Kanai K, Isose S, Shibuya K, Noto Y, et al. Altered axonal excitability properties in juvenile muscular atrophy of distal upper extremity (Hirayama disease). Clin Neurophysiol. 2011;122(1):205-9.
13. Preethish-Kumar V, Nalini A, Singh RJ, Saini J, Prasad C, Polavarapu K, et al. Distal bimelic amyotrophy (DBMA): Phenotypically distinct but identical on cervical spine MR imaging with brachial monomelic amyotrophy/Hirayama disease. Amyotroph Lateral Scler Frontotemporal Degener. 2015;16(5-6):338-44.
14. Hassan KM, Sahni H, Jha A. Clinical and radiological profile of Hirayama disease: A flexion myelopathy due to tight cervical dural canal amenable to collar therapy. Ann Indian Acad Neurol. 2012;15(2): 106-12.
15. Sonwalkar HA, Shah RS, Khan FK, Gupta AK, Bodhey NK, Vottath S, et al. Imaging features in Hirayama disease. Neurol India. 2008;56(1):22-6.
16. Baba Y, Nakajima M, Utsunomiya H, Tsuboi Y, Fujiki F, Kusuhara T, et al. Magnetic resonance imaging of thoracic epidural venous dilation in Hirayama disease. Neurology. 2004;62:1426-8.
17. Khadilkar S, Patel B, Bhutada A, Chaudhari C. Do longer necks predispose to Hirayama disease? A comparison with mimics and controls. J Neurol Sci. 2015;359(1-2):213-6.
18. Hou C, Han H, Yang X, Xu X, Gao H, Fan D, et al. How does the neck flexion affect the cervical MRI features of Hirayama disease? Neurol Sci. 2012;33(5):1101-5.
19. Wang H, Tian Y, Wu J, Sun C, Nie C, Zheng C, et al. The radiological and electrophysiological characteristics of Hirayama disease with proximal involvement: A retrospective study. Front Neurol. 2022;13:969484.
20. Bede P, Walsh R, Fagan AJ, Hardiman O. "Sand-watch" spinal cord: a case of inferior cervical spinal cord atrophy. J Neurol. 2014;261(1):235-7.
21. Liao MF, Chang HS, Chang KH, Ro LS, Chu CC, Kuo HC, et al. Correlations of clinical, neuroimaging, and electrophysiological features in Hirayama disease. Medicine (Baltimore). 2016;95(28):e4210.
22. Zou F, Yang S, Lu F, Ma X, Xia X, Jiang J. Factors Affecting the Surgical Outcomes of Hirayama Disease: A Retrospective Analysis of Preoperative Magnetic Resonance Imaging Features of the Cervical Spine. World Neurosurg. 2019;122: e296-301.
23. Boruah DK, Prakash A, Gogoi BB, Yadav RR, Dhingani DD, Sarma B. The Importance of Flexion MRI in Hirayama Disease with Special Reference to Laminodural Space Measurements. AJNR Am J Neuroradiol. 2018;39(5):974-980.
24. Lehman VT, Luetmer PH, Sorenson EJ, Carter RE, Gupta V, Fletcher GP, et al. Cervical spine MR imaging findings of patients with Hirayama disease in North America: a multisite study. AJNR Am J Neuroradiol. 2013;34(2):451-6.
25. Chen CJ, Hsu HL, Tseng YC, Lyu RK, Chen CM, Huang YC, et al. Hirayama flexion myelopathy: neutral-position MR imaging findings—importance of loss of attachment. Radiology. 2004;231(1):39-44.
26. Shao M, Yin J, Lu F, Zheng C, Wang H, Jiang J. The Quantitative Assessment of Imaging Features

JAYPEE BROTHERS

for the Study of Hirayama Disease Progression. Biomed Res Int. 2015;2015:803148.
27. Lai V, Wong YC, Poon WL, Yuen MK, Fu YP, Wong OW. Forward shifting of posterior dural sac during flexion cervical magnetic resonance imaging in Hirayama disease: an initial study on normal subjects compared to patients with Hirayama disease. Eur J Radiol. 2011;80(3):724-8.
28. Singh NA, Viswanathan VK, Shetty AP, Kanna RM, Rajasekaran S. Diffusion Tensor Imaging Characteristics in Hirayama Disease: Case Report and Review of the Literature. World Neurosurg. 2020;140:180-7.
29. Abraham A, Gotkine M, Drory VE, Blumen SC. Effect of neck flexion on somatosensory and motor evoked potentials in Hirayama disease. J Neurol Sci. 2013;334(1-2):102-5.
30. Fu Y, Qin W, Sun Q, Fan D. Investigation of the compliance of cervical collar therapy in 73 patients with Hirayama disease. Natl Med J China. 2016;96:3485-8.
31. Lyu F, Zheng C, Wang H, Nie C, Ma X, Xia X, et al. Establishment of a clinician-led guideline on the diagnosis and treatment of Hirayama disease using a modified Delphi technique. Clin Neurophysiol. 2020;131:1311-9.
32. Brandicourt P, Sol JC, Aldéa S, Bonneville F, Cintas P, Brauge D. Cervical laminectomy and micro resection of the posterior venous plexus in Hirayama disease. Neurochirurgie. 2018;64(4):303-9.
33. Zhang H, Wang S, Li Z, Shen R, Lin R, Wu W, et al. Anterior Cervical Surgery for the Treatment of Hirayama Disease. World Neurosurg. 2019;127:e910-8.
34. Bohara S, Garg K, Mishra S, Tandon V, Chandra PS, Kale SS. Impact of various cervical surgical interventions in patients with Hirayama's disease—a narrative review and meta-analysis. Neurosurg Rev. 2021;44(6):3229-47.
35. Song J, Wang HL, Zheng CJ, Jiang JY. Risk factors for surgical results of Hirayama disease: a retrospective analysis of a large cohort. World Neurosurg. 2017;105:69-77.
36. Moglia C, Calvo A, Cammarosano S, Ilardi A, Canosa A, Gallo S, et al. Monomelic amyotrophy is not always benign: a case report. Amyotroph Lateral Scler. 2011;12(4):307-8.
37. Lu F, Wang H, Jiang J, Chen W, Ma X, Ma X, et al. Efficacy of anterior cervical decompression and fusion procedures for monomelic amyotrophy treatment: a prospective randomized controlled trial: clinical article. J Neurosurg Spine. 2013;19:412-9.
38. Guo X, Lu M, Xie N, Guo Q, Ni B. Multilevel anterior cervical discectomy and fusion with plate fixation for juvenile unilateral muscular atrophy of the distal upper extremity accompanied by cervical kyphosis. J Spinal Dis Techn. 2014;27:E241-6.
39. Lin MS, Kung WM, Chiu WT, Lyu RK, Chen CJ, Chen TY. Hirayama disease. J Neurosurg Spine. 2010;12(6):629-34.

JAYPEE BROTHERS

for detailed information on neurology books, visit our website www.jaypeebrothers.com, for detailed information on neurology books, visit our website v

Advances in Neuromuscular Disorders

Salient Features

- This book is designed to provide a comprehensive understanding of diagnostic and management strategies for neuromuscular disorders, along with basic clinical knowledge.
- Chapters provide foundational knowledge and advancements in clinical diagnosis, bridging the gap between clinical diagnosis and practical management aspects.
- Numerous eminent neurologists have contributed to it, making sure that it accurately represents the most recent findings, clinical recommendations, and developing therapeutic approaches.
- It includes case studies and clinical scenarios to help contextualize the material and facilitate practical learning.

Debashish Chowdhury DTCD MD(Medicine) DM(Neurology) FIAN FRCP(Edinburgh) Commonwealth Fellow in Stroke Medicine (Edinburgh) is currently working as the Director–Professor and Head, Department of Neurology, GB Pant Institute of Postgraduate Medical Education and Research, New Delhi, India. He is a Commonwealth Fellow in Stroke Medicine (Edinburgh, UK). He has more than 150 publications to his credit in national and international indexed journals and served as Editor/Co-editor of 15 books and 2 journal supplements. He is the President of the Indian Academy of Neurology and the President of Delhi Neurological Association. He is a Distinguished Alumnus of Maulana Azad Medical College, New Delhi, India. Because of his continuous dedicated work in headache medicine for the past 20 years, he is currently considered the face of headache medicine in India.

Atchayaram Nalini DM PhD, is Professor of Neurology and a Neuromuscular Specialist, who leads the National Institute of Mental Health and Neurosciences (NIMHANS), Bengaluru, Karnataka, India, an advanced center for neuromuscular disorders (NACNMD). She joined NIMHANS as faculty in the year 1999 and since then has been passionately involved in the phenotyping and genotyping of inherited neuromuscular disorders. She conducts the only kind of Multidisciplinary Neuromuscular Disorders Clinic and Motor Neuron Disease Clinic. She is instrumental in commencing the postdoctoral fellowship in neuromuscular disorders. Her role has been crucial in establishing the neurogenetics facility, particularly for inherited neuromuscular disorders. She has been the pathfinder and along with her neurosurgical colleagues laid the foundation for initiation of surgical intervention in Hirayama disease. She has the largest series of registered patients with motor neuron disease. She indulges in advanced technological diagnosis and management of patients with neuromuscular disorders.

Vishnu VY MD DM is Additional Professor of Neurology, All India Institute of Medical Sciences (AIIMS), New Delhi, India, and Incharge AIIMS-Comprehensive Neuromuscular Disorders Clinic. He completed his undergraduate training from GMC, Thiruvananthapuram; Internal Medicine Residency from JIPMER, Puducherry; and Neurology Residency from PGIMER, Chandigarh. He has worked as Assistant Professor in Neurology at PIMS, Puducherry and PGIMER, Chandigarh before joining as regular faculty at AIIMS, New Delhi. He is a faculty fellow of the International Centre for Genomic Medicine in Neuromuscular Diseases (ICGNMD) and participant of the first cohort of World Stroke Organizations Future Leaders Programme. His fields of interest are neuromuscular disorders, stroke, machine learning, and evidence-based medicine. In the neuromuscular field, his research focus is on facioscapulohumeral muscular dystrophy (FSHD), limb girdle muscular dystrophy, distal myopathies, inflammatory myositis, and young-onset motor neuron disease. He established the largest genetically characterized cohort of FSHD in India.

Printed in India

Available at all medical bookstores or buy online at www.ejaypee.com

JAYPEE BROTHERS
Medical Publishers (P) Ltd.
EMCA House, 23/23-B, Ansari Road, Daryaganj, New Delhi - 110 002, INDIA
www.jaypeebrothers.com

Join us on facebook.com/JaypeeMedicalPublishers
Follow us on instagram.com/JaypeeMedicalPublishers

Shelving Recommendation
NEUROLOGY

ISBN 978-93-6616-198-3