Kosnin NA[1], Ghazali FR[1], Aziz ME[1]

[1]Department of Radiology, School of Medical Sciences, Universiti Sains Malaysia, Health Campus, 16150 Kubang Kerian, Kelantan, Malaysia

*Corresponding author
Fattah Rahiman Ghazali
fattahrahiman@usm.my

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Owl-Eyes Sign of the Spinal Cord in Spinal Muscular Atrophy

Abstract – The "owl-eyes" sign is a rare and unique radiological finding that can be seen in the anterior horn cells of the spinal cord as bilateral symmetrical hyperintense circular or ovoid foci on T2-weighted (T2W) axial magnetic resonance imaging (MRI) sequences. There are various clinical conditions that have been linked to this sign, as in our case report, it is seen in a case of spinal muscular atrophy. We report a case of 16-year-old male patient who had no known medical illness and presented with deformity of the back for the past one year without any neurological deficit. His MRI whole spine showed thoracic spine scoliosis with "owl-eyes'' sign in the spinal cord as well as left erector spinae muscle atrophy, leading to the diagnosis of spinal muscular atrophy.

Keywords – *''Owl-eyes'' sign, magnetic resonance imaging (MRI), scoliosis, spinal muscular atrophy*

1 INTRODUCTION

Spinal muscular atrophy (SMA) refers to a group of autosomal recessive disorders causing muscle atrophy and weakness as a result of motor neuron degeneration in anterior horn cells of the spinal cord (1). It has an estimated incidence of 1 in 6,000 to 1 in 10,000 live births and a carrier frequency of 1 in 50, making it the second most prevalent fatal autosomal recessive illness after cystic fibrosis (2). This disorder is most commonly caused by chromosome 5q13 mutations in the survival motor neuron 1 (*SMN1*) gene, which exists in two forms (a telomeric/SMN1 and centromeric/SMN2) on each allele in humans (1,3). Due to the dysfunctional gene, motor neuronal death and subsequent loss of motoric functions can occur, leading to muscle weakness and atrophy, and sometimes gastrointestinal and respiratory problems. Delayed diagnosis of SMA can affect the disease progression, in which the weakened muscle may lead to skeletal deformities such as thoracolumbar scoliosis, pelvic obliquity, and hip subluxation/dislocation (3).

Scoliosis is an abnormal lateral spinal curvature exceeding 10 degrees of the Cobb angle. About 80 % of scoliosis cases are idiopathic while the rest are secondary to other causes, either congenital, or developmental osseous or neuromuscular abnormalities (4). One of the secondary causes is SMA.

Imaging findings of SMA vary according to the type; one of the reported features is the "owl-eyes" sign in the spinal cord magnetic resonance imaging (MRI). We present a case of thoracic spine scoliosis with unilateral erector spinae muscle atrophy and a unique MRI finding of "owl-eyes'' sign in the spinal cord, leading to the diagnosis of SMA.

2. CASE REPORT

A 16 years old Malay boy with no known medical illness presented to the orthopaedic clinic with deformity of the back for the past 1 year. It was associated with mild back pain occasionally. Patient had never previously sought treatment. Otherwise, the patient was able to perform activities of daily living independently and ambulate well without any aid. Patient had no history of trauma or prior hospitalizations, no signs or symptoms of limb weakness, and no urine or bowel incontinence. He was born full term via spontaneous vaginal delivery without any complication. The patient's developmental milestones during childhood were appropriate for his age. There is no family history of similar problem. Upon examination, a right upper back hump with right shoulder tilt were noted. Neurological examination of both upper limbs and lower limbs were intact.

The thoracic spine dextroscoliosis was seen on the initial whole spine radiograph (Figure 1A). MRI whole spine was performed and revealed severe dextroscoliosis of the thoracic spine with mild secondary scoliosis at the lower cervicothoracic junction and lumbar spine. The apex of scoliosis at

the T9 vertebra with Cobb's angle measures 57 degrees (Figure 1B). Focal T2 hyperintensities are also noted at the anterior aspect of the spinal cord on axial MRI, which resembles the ''owl-eyes'' sign, from the level of T5/T6 disc to upper T7 vertebral body, measuring 2.1 cm in length (Figure 2). The left erector spinae muscle at the level of T7 to T11 is smaller in size as compared to the right, with prominent intramuscular fatty tissue (Figure 3). Overall MRI features are suggestive of SMA. Unfortunately, the electromyography and nerve conduction study for neuromuscular electrodiagnostic test, as well as SMN1 gene test for genetic diagnosis were not conducted for the time being due to financial difficulties.

Subsequently, the patient underwent scoliosis correction surgery with 14 pedicle screws, 3 rods and 2 crosslinks were inserted to correct the scoliosis. Paraspinal muscle tissues were examined during surgery, and they appeared healthy. Biopsy of left erector spinae muscle was taken and sent to the lab for histopathological examination which showed atrophied muscle fibres with evidence of vasculitis. He was discharged well after day 5 of operation.

At a few months follow up, the patient was healthy with no active complaint. The mild back pain was completely resolved. He was able to carry out daily activities independently. On examination, there was no neurological deficit and the previously seen right upper back hump was resolved. However, the right shoulder tilt still persists.

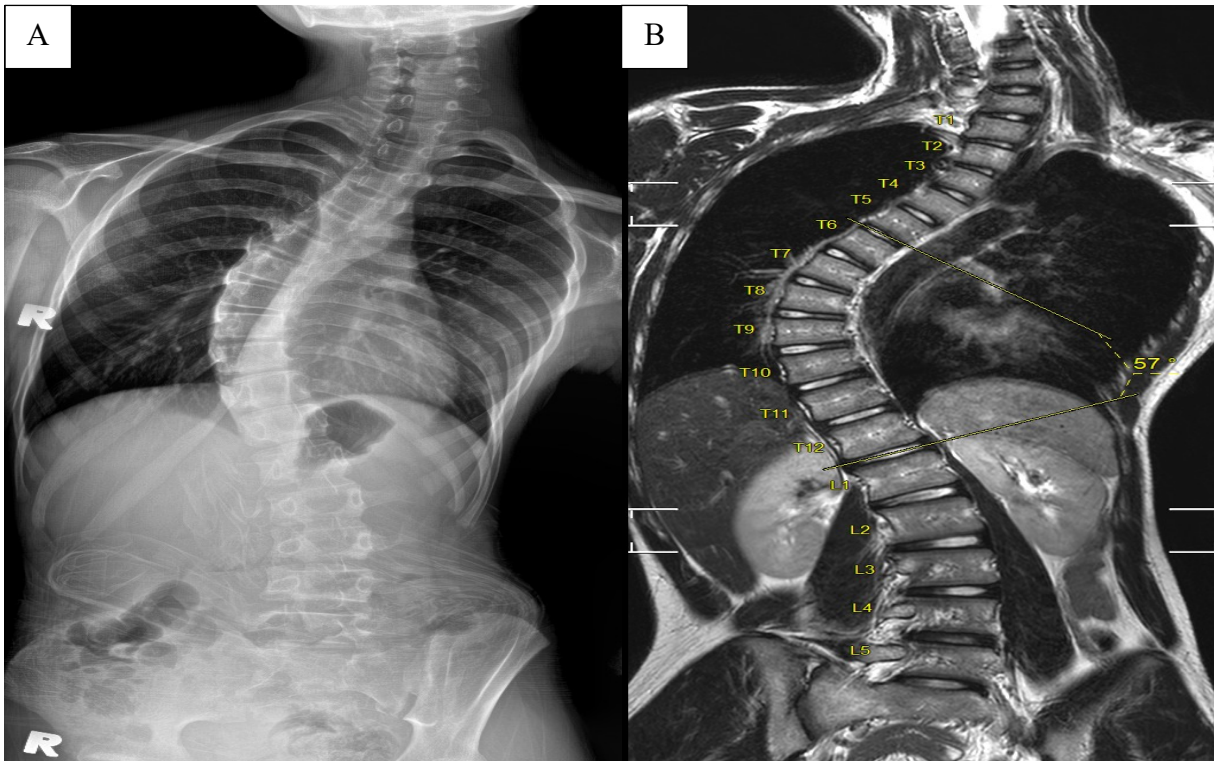

Figure 1. Frontal whole spine radiograph (A) and corresponding T2-weighted MRI whole spine in coronal view (B), shows severe thoracic dextroscoliosis with apex at T9 vertebra and Cobb angle of 57°

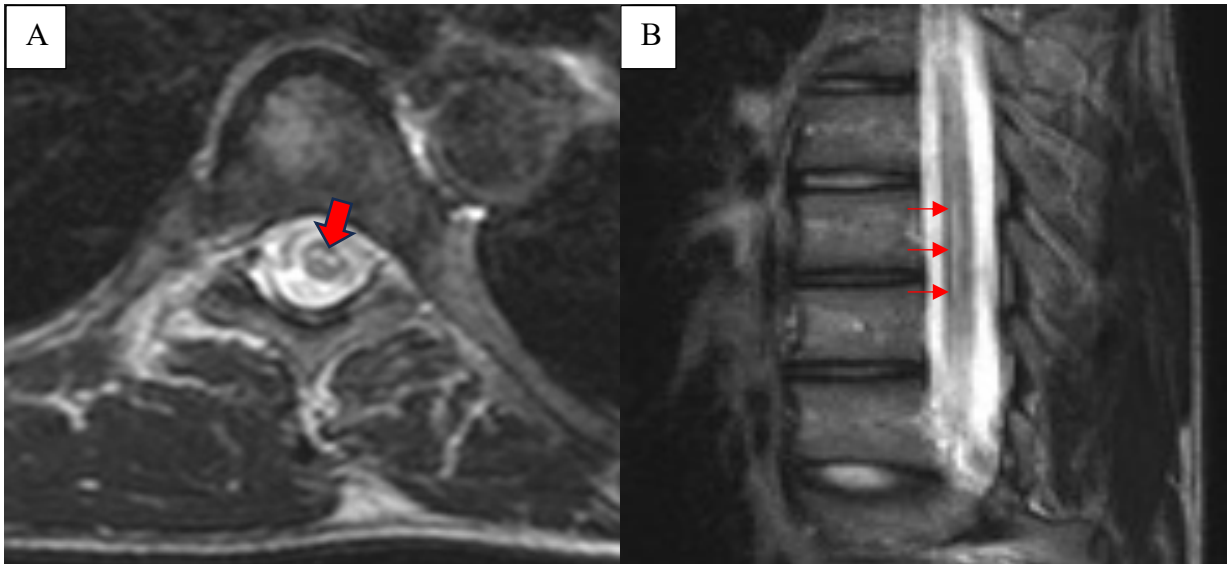

Figure 2. T2-weighted MRI in axial (A) and sagittal (B) views, shows hyperintense foci at the right and left anterior part of the spinal cord resembling "owl-eyes" sign (thick arrow in A) and pencil-like vertical hyperintensity (thin arrows in B) at the corresponding level of T6 vertebra

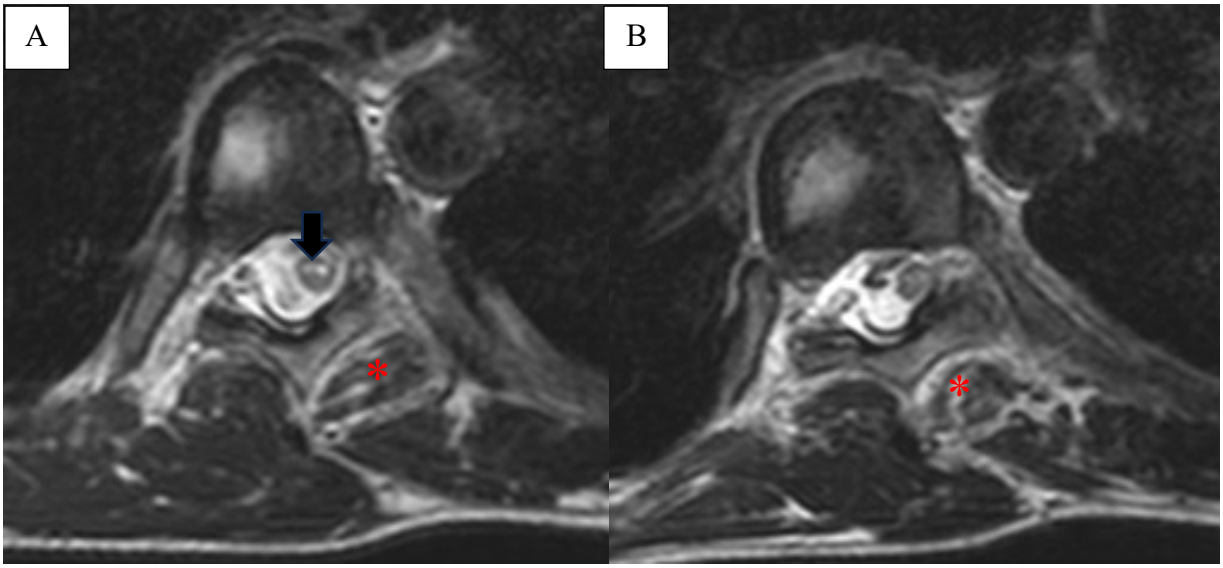

Figure 3. T2-weighted MRI in axial views at the level of T7 (A) and T9 (B) vertebrae, shows atrophy of the left erector spinae muscle with prominent intramuscular fatty tissue in keeping with fatty infiltration (asterisks in A & B). Note the presence of "owl-eyes" sign (arrow in A)

3. DISCUSSION

SMA is classified based on age of onset and maximum motor function achieved. Type 1 or also known as Werdnig–Hoffman disease: infants younger than 6 months of life who present with hypotonia, poor head control, and reduced or absent tendon reflexes. By definition, they never achieve the ability to sit unassisted. Type 2: children younger than 18 months who are able to sit unassisted at some point during their development; however, they are never able to walk independently. Type 3 or also known as Kugelberg–Welander disease: patients are generally older than 18 months and are able to walk without support at some point in their life. There is subdivision of type III which are Type IIIa manifests itself up to the age of three years and

type IIIb over the age of three years. Type 4: onset is in adulthood (> 21 years) with the mildest form of the disease who walk independently. Some authors suggest an additional SMA type 0, used to describe neonates who present with severe weakness and hypotonia with a history of decreased fetal movements. Life expectancy for type 0 is reduced, and most are unable to survive beyond 6 months of age (5).

A study conducted in Indonesia found that more than half of their SMA patients had spinal deformities which include scoliosis, kyphosis and lordosis. They also revealed that type 2 SMA, the most common type in their study, has a twofold risk of the spinal deformities. Their result may be due to a higher survival rate in type 2 SMA making progression of the spinal deformities more evident. Other finding was delayed diagnosis is most common in type 3 SMA, due to late clinical manifestation. Majority of their patients were diagnosed by DNA testing. However, it is costly and not all hospitals have the genetic and other supporting test, hence contributing to the delayed diagnosis (3).

The MRI findings in SMA will vary depending on the SMA type. However, to date and to the best of our knowledge, there is no extensive description in the literature. Liu et al. in 1992 evaluated the MRI findings according to Dubowitz's classification of SMA. Patients with the most severe forms of SMA typically will have visible muscle atrophy without fatty infiltration and may have more prominent subcutaneous tissue. Patients with intermediate forms of SMA typically have a muscle atrophy with a ragged appearance or patches of MR signal abnormality within the affected muscles. SMA with milder forms are more likely to have fatty infiltration with increased size of the intramuscular fat planes and reduced muscle volumes with MR signal abnormalities in the affected muscles (6). The latter changes were seen within the left erector spinae muscle of our patient.

Another MRI finding in our patient is the presence of "owl-eyes" sign within the anterior part of the spinal cord from T5/T6 to T7 level. The "owl-eyes" sign, also known as the "snake-eyes" or "fried-eggs" sign, refers to bilateral hyperdense or hyperintense symmetric, circular or ovoid foci in the anterior horn cells of the spinal cord on delayed computed tomography (CT) myelography or T2-weighted (T2W) axial MRI images (7-11). In 1985, Iwasaki et. al. described their findings in delayed CT myelography of cervical spondylosis patients as two small high-density areas in the grey matter of spinal cord, resembling "fried eggs" (8). Not long after, in the subsequent year, Jinkins *et. al.* reported similar findings by the same imaging modality in a series of compressive cervical myelopathy patients but instead called it as the "snake-eyes" sign (9). On the other hand, the term "owl-eyes" sign is thought to be coined by Mawad *et. al.* in 1990, in which they used it to describe two distinct foci high signal intensity limited to anterior horns of grey matter on T2W axial MRI and recognised it as one of the MRI signal abnormality patterns in patients with spinal cord ischaemia after thoracoabdominal aortic aneurysms resection (10). The spinal cord changes in these studies (CT and MRI) were thought due to ischaemia, which either represent necrosis with subsequent grey matter cavitation, or grey matter oedema due to infarction in the distribution of the anterior spinal artery (8-10). Hsu *et. al.* (1998) reported similar MRI findings as Mawad *et. al.* in a case of type 1 SMA (Werdnig–Hoffman disease) which was thought to correspond to motor neuron loss and swollen cells (11).

The ''owl-eyes'' sign has also been described in association with other clinical conditions such as degenerative cervical myelopathy, Hirayama disease or monomelic amyotrophy of the upper limb, and amyotrophic lateral sclerosis. Although this sign typically described as one of the patterns in spinal cord infarction affecting the anterior spinal artery as well as in multiple other clinical settings, there is no clear data about its exact prevalence and incidence for each condition. Some studies suggest that it is much more common than it might be believed (7). Furthermore, the pathophysiology and prognostic significance of this sign is still unclear and not well established as the current literature shows conflicting results and discrepancy between clinical, radiological and histopathology (7,12). Nonetheless, we highlight this unique MRI finding in association with muscle atrophy and scoliosis as an important radiological feature for SMA, with the intention of aiding the physician in arriving to the definitive diagnosis and commencing prompt treatment.

4. CONCLUSION

MRI findings in SMA vary depending on the type. In the skeletal muscle, the predominant MRI features are those of muscle atrophy, with or without fatty infiltration. The ''owl eyes'' of the spinal cord in T2W axial MRI sequences may be present although it is also seen in other clinical conditions and neither specific nor pathognomonic for any type of SMA. Although the pathophysiology of this sign as well as its clinical and prognostic

significance are still not well understood, we highlighted this unique sign as it is believed to be much more common and can serve as an important radiological feature in SMA.

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CONSENT FOR PUBLICATION

Verbal consent was granted from the patient for the publication of this case report and the accompanying images. Institutional Review Board approval is not required at the authors' institutions for the presentation of a single case report.

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