ORIGINAL ARTICLE

Association of Cobb angle progression and neuraxial abnormality on MRI in asymptomatic Adolescent Idiopathic Scoliosis

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ABSTRACT

Background: Detection of neuraxial abnormality in neurologically asymptomatic adolescent idiopathic scoliosis (AIS) is crucial prior to surgery. It can only be detected on magnetic resonance imaging (MRI), which was not routinely done in this group of patient. On the other hand, whole spine radiographs for measurement of Cobb angle have been routinely included during clinic follow-up. This study aimed to determine the correlation between Cobb angle progression and neuraxial abnormality finding on MRI in asymptomatic AIS.

Methods: A retrospective study was conducted in the Orthopaedic department of a tertiary hospital. Patients with asymptomatic AIS aged 10-20 years who attended scoliosis clinic from year 2007 to 2010 was reviewed. Patients who had whole spine MRI and two vertebral radiographs at least one year apart were further selected. Statistical analysis was done to see the association between Cobb angle progression and neuraxial abnormality on MRI.

Results: The mean age at first presentation was 14.4 years old. Female (n=249) to male (n=50) ratio was 5:1. Only 19 patients fulfilled the selection criteria. There were 5 patients (26.3%) who had neuraxial abnormalities. The mean curve progression was 7.05° (range from -5° to 28°). Patients with and without neuroaxial abnormality showed mean curve progression of 0.6° and 9.36° respectively. There was no significant association between Cobb angle progression and neuroaxial abnormality (p=1.000).

Conclusion: Cobb angle progression is not a reliable indicator for predicting neuroaxial abnormality in patients with asymptomatic AIS. However, this study stressed the need to perform MRI prior to operation to document any associated neuraxial abnormality in clinically asymptomatic AIS patients.

KEY WORDS:
Adolescent Idiopathic Scoliosis, Cobb angle progression, magnetic resonance imaging, neuraxial abnormality

INTRODUCTION

According to Scoliosis Research Society, adolescent idiopathic scoliosis (AIS) is defined as scoliosis in patients above ten years of age to skeletal maturity, which accounts for the majority of idiopathic scoliosis cases. [1-5] Many studies have documented that neuraxial pathologic conditions can be caused by or associated with scoliosis. [6-8] A surgical fusion over intraspinal pathology often leads to serious consequences. Pre-existing syringomyelia, Chiari malformation, tethered cord and intraspinal tumours can be risk factors for neurological injury following surgical correction of scoliosis.[9] Often the underlying neuroaxial abnormality was unsuspected especially when the clinical finding is not neurologically significant. Therefore, magnetic resonance imaging (MRI) is the method of choice for imaging the spinal pathology prior to surgery. [6-8]

Several studies have published the factors predicting the presence of neuroaxial abnormality, which includes patients with neurological findings, early onset of scoliosis and apical kyphosis. [8, 10, 11] However, the majority of scoliosis cases are idiopathic (80%) and asymptomatic. [5] Patients are usually followed-up with thoracolumbar radiograph for assessment of the Cobb angle together with patients' symptoms. Reported rates of curve progression vary from 1.6% - 68% in a year interval, depending on skeletal maturity and curve magnitude. [4]

The aim of the present study was to determine whether the curve progression of Cobb angle could be used as a clinico-radiological indicator to predict the findings of neuraxial abnormalities. This will hopefully guide the decision for selecting patients for MRI investigations whenever they are neurologically asymptomatic.

MATERIALS AND METHODS

Patients with asymptomatic AIS, who were referred to the scoliosis clinic in our hospital from the year 2007 to 2010, were recruited into this study. Retrospective study was done based on the data obtained from patients' medical notes and radiographs from the Medical Record Unit and local hospital PACS server (Medweb®). This study has been approved by the institution's Ethical Committee and funded by the hospital.

All patients without neurological symptom and who were diagnosed to have idiopathic scoliosis at the age ranging from 10 to 20 years old were included for demographic analysis. However, in order to statistically determine the

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Table I: Association (contingency) between presence of Cobb angle progression and neuraxial abnormality. There was no significant difference in proportions (p = 1.000)

Group		Neuraxial abnormality on MRI		Total
		Present	Absent	
Curve progression in two vertebral radiograph	Present	1	4	5
	Absent	4	10	14
Total		5	14	19

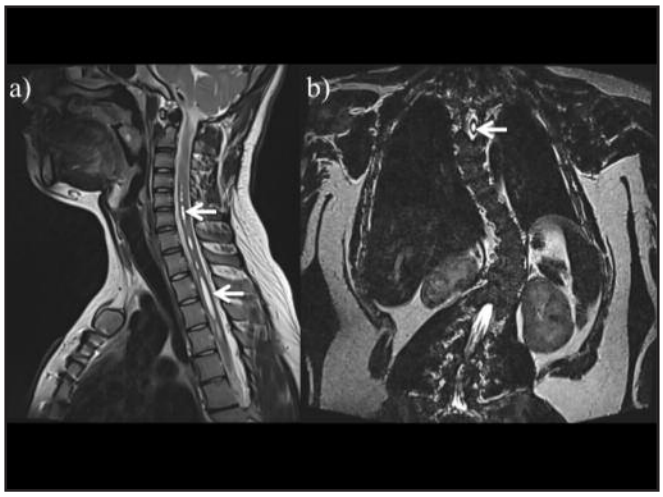

Fig. 1: MRI whole spine in sagittal T2WI (a) and coronal heavily T2WI (b) shows long segment syringomyelia at cervical and thoracic cord (arrows).

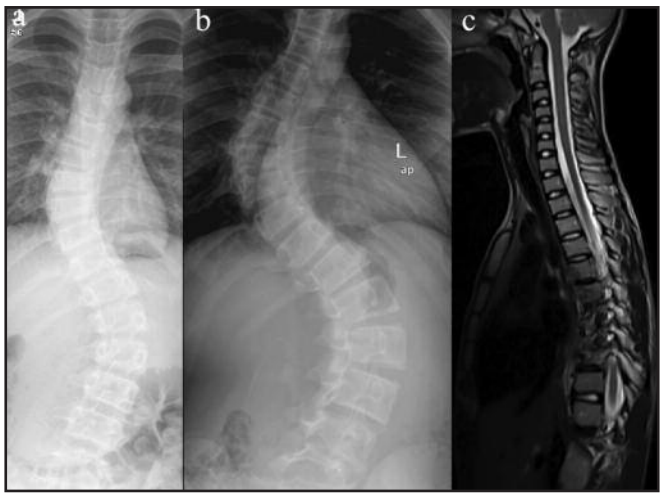

Fig. 3: Thoracolumbar radiographs done in (a) 2009 and (b) 2010 shows double curvature of thoracic and lumbar scoliosis with curve progression of 21.5o. (c) MRI whole spine sagittal T2WI demonstrates no evidence of neuraxial abnormality.

correlation between Cobb angle progression and neuraxial abnormality, we only included those who fulfilled our inclusion criteria: 1) patient with two pre-MRI vertebral radiographs that were at least one year apart and 2) a complete whole spine MRI was performed. In this study, a difference of 5° or more in the Cobb angles of the two vertebral radiographs was considered as significant Cobb

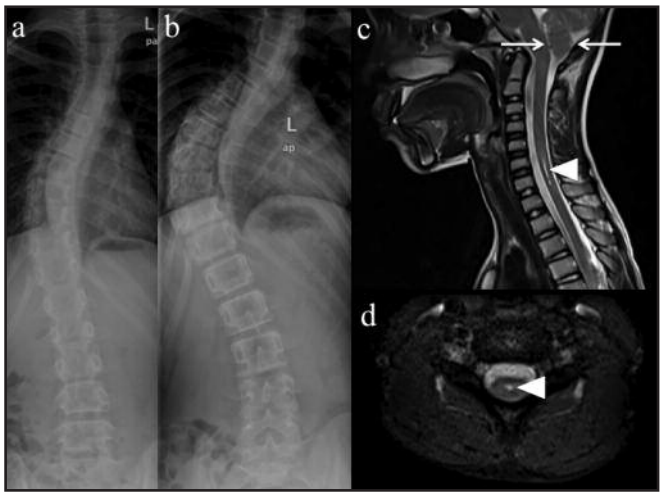

Fig. 2: Imaging for patient with curve progression and MRI proven neuraxial abnormality. (a) and (b) show thoracolumbar radiographs of the patient in 2008 and 2009 respectively which demonstrate curve progression of 26.5o. MRI wholespine (c) and (d) sagittal and axial T2WI reveals tonsilar herniation (arrows) and syringomyelia (arrowhead) consistent with Chiari I deformity.

angle progression. This definition was based on previous published studies. [1,2,12,13] The exclusion criteria were patient's age below 10 years old or above 20 years old, patient with neuromuscular symptoms, the two vertebral radiographs were done less than one year apart and no MRI images available for interpretation.

The researchers interpreted the radiographs whereas only the radiologist interpreted the MRIs. The researchers were medical undergraduates in the hospital who had undergone their training in orthopaedics and had personal training in measurement of Cobb angle by a radiologist. Each Cobb angle was measured by two researchers using the same vertebra level and the average of the measurements were calculated. The curves were measured by Cobb's techniques as recommended by the Scoliosis Research Society. Full whole spine MRI protocol for examination of neuraxial abnormalities from the skull to the coccyx included sagittal whole spine T1WI and T2WI, axial T1WI and T2WI (at the abnormal level) and coronal T2WI, and was performed using either Magnetom 1.5T (Siemens, Germany) or Avanto 1.5T (Siemens, Germany).

Neuraxial or sometimes called neuraxis is defined as the unpaired part of the central nervous system, which incorporates the intraspinal component including the spinal cord as well as the vertebral body abnormality.

Statistical Analysis
Statistical analysis was done using SPSS 16.0 for Windows®. Student t-test for independent groups was used to compare the means of the Cobb angle progression between the two groups (presence versus absence of neuraxial abnormality on MRI). Fisher's Exact test was applied for analysis of association (contingency) between Cobb angle progression and neuraxial abnormality. A *p* value of <0.05 was considered to be significant.

RESULTS

Demographics
Total of 299 patients with AIS attended scoliosis clinic in our hospital from year 2007 to 2010. The mean age at first presentation was 14.4 years old with a standard deviation of 2.23 years. Females (83.3%) had a higher prevalence than males (16.7%), with the ratio of 5:1. There were 158 Malay patients (52.8%), 126 Chinese patients (42.1%), 14 Indian patients (4.7%) and one patient (0.3%) from the other races.

Out of the 299 patients with AIS, only 52 patients had MRI spine done during the course of treatment with 16 cases showing abnormality (28%). Out of the 52 patients with MRI, only 19 patients fulfilled the criteria of having two pre-MRI vertebral radiographs, which were at least one year apart.
Five out of the 19 patients above (26.3%) had neuraxial abnormalities. There were three cases of syringomyelia (Figure 1), one case of syringomyelia with Chiari 1 deformity, and one case of T1 lesion of a non-fatty atypical hemangioma.

Cobb angle curve progression and MRI findings
The mean Cobb angle curve progression of the 19 patients was 7.05° (range 5° to 28°) with a standard deviation of 4.8°. The mean curve progression in the group where neuraxial abnormality was present and absent was 0.6° and 9.36° respectively. However, the difference in mean Cobb angle progression value between the two groups was not statistically significant; Student t-test (p= 0.062).

Among the five patients who demonstrated abnormal neuraxial findings on MRI, there was only one patient with curve progression (Figure 2). Four patients who demonstrated curve progression did not have any neuraxial abnormality depicted on MRI (Figure 3). Table 1 shows that the association (contingency) between the presence of Cobb angle progression with the presence of neuraxial abnormality was not statistically significant (p=1.000).

DISCUSSION

The mean age at first presentation in our subject population was similar to that seen in previous studies. Etemadifar et al reported a mean age of 15 years old while Ozturk et al reported a mean age of 14.3 years old. [14,15] Oh *et al* reported a mean age of 16.3 years old in his study of 205 patients with idiopathic scoliosis in Kuala Lumpur General Hospital, Malaysia from 1985 to 2000. [16] The mean age at first presentation of our study was less as compared to his study. This could be attributed to the improvement in the quality of health care service especially the National Scoliosis Screening Program for school children and increased public awareness of scoliosis.

A previous study showed the majority of curve progression is between 5°-9° within one year.[1] In the study by Evans *et al,* 20 patients who were observed for six months before surgery, had a mean curve progression of 7.6°/year (–10° to 44°), which is comparable to this study whereby the mean curve progression was 7.05°/year (-5° to 28°). [17] The negative value indicates the improvement of the scoliosis curvature, which can be due to effective conservative treatment such as bracing and physiotherapy. In our center, all patients were offered conservative management as the first line treatment. In fact, previous studies showed spontaneous improvement of Cobb angle in 22% to 27% of untreated scoliosis patients who were followed up in one year. [1,18]

Evans *et al* also reported mean curve progression of 9.8°/year and 6.9°/year in the subgroup of neuraxial abnormality and normal cases respectively. [17] However, this study showed a higher mean Cobb angle progression in patients without neuraxial abnormality compared to patients with neuraxial abnormality, contradicting the results in the Evans study. In the present study, we were unable to recruit all the AIS patients from the time frame, since patients with big curvature usually had surgical management without prior MRI spine or repeated vertebral radiographs done. There was another group of patients who had been referred from other centers for surgery but did not have the two vertebral radiographs taken one year apart to enable the curve progression evaluation. In addition, all of our patients underwent conservative management such as bracing and physiotherapy, which could have contributed to the lesser degree or even improvement of Cobb angle progression in some of the patients.

A previous study done in 2006 reported 20.5% of the AIS patients had neural axis abnormalities on MRI, which were Arnold-Chiari malformation (n=3), Arnold-Chiari malformation associated with syrinx (n=2), diastematomyelia (n=1), plexiform neurofibroma (n=1) and arachnoid cyst (n=1). [19] Syringes and Chiari malformations were the most frequent abnormalities in patients with AIS (66.7% and 30.7% respectively), whereas tethered cords were rare (2.6%). [20] The present study showed that syringomyelia has the highest incidence among the subject population. The association of scoliosis with syringomyelia is well established. [21,22] The risk of neurological injury during instrumented correction of scoliosis without prior decompression of an associated syrinx has already been documented. [23-25] Early detection of a syrinx by MRI may therefore be of particular value. There have been several reports of scoliosis as the presenting feature of an intramedullary cord tumour without neurological sign or symptom, which further stress the importance of preoperative MRI evaluation. [26]

There were few clinical presentation which could be the factors determining neuraxial abnormality in asymptomatic AIS patients which warrants pre-operative MRI screening. These include left thoracic curvature, rapid curve progression, apical kyphosis and neurological complaints and findings. [27]

Present study on Cobb angle progression of 5° or more showed no significant correlation between Cobb angle progression and presence of neuraxial abnormality in asymptomatic AIS. Originally it was understandable that there would be no tendency of curve progression once the skeletal maturity is reached literally upon adolescence time.[28] However there were studies done which demonstrated that the progression of the curve will indeed occur after skeletal maturity is reached especially if the curve is more than 30° .[29] There are also several other factors that contribute to curve progression such as gender, curve pattern and curve magnitude and therefore it shows that curve progression may vary among individuals and may be multifactorial.[30]

The present study had several limitations such as:

1. It was a retrospective review and therefore, some of the patients with large Cobb angle had operation without pre-operative MRI and/or with only one vertebral body radiograph, and were excluded in this study.
2. The effect of conservative management was not considered as one of the factors affecting the Cobb angle in this study since some of the patients even had improvement of the Cobb angle on the second vertebral radiograph. This limitation is mainly contributed by the retrospective nature of the study.
3. Cobb angle is a 2D assessment of a 3D pathology of scoliosis. Therefore, the measurement of Cobb angle is bound to measurement error. However, since the practice of measuring Cobb angle is widely used by the orthopaedic surgeon on follow-up of scoliosis, this triggered the authors to assess whether Cobb angle progression can predict neuraxial abnormality in asymptomatic patients.
4. We decided to take an interval of 1-year between the two vertebral body radigraphs since our center normally follow-up the patients yearly with vertebral body radiograph. On the other hand, Evans et al performed a prospective study and follow up their patients in six month to evaluate the curve progression.[17] Therefore, a prospective study needs to be done in the future considering all the factors discussed above to obtain a significant association between Cobb angle progression and neuraxial abnormality.

As the conclusion, based on the present study, Cobb angle progression is not a reliable factor in predicting neuraxial abnormality. Since Cobb angle progression is multifactorial, we advocate MRI spine imaging to be performed prior to surgery to document any associated neuraxial abnormality in asymptomatic AIS.

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