The use of routine preoperative magnetic resonance imaging in identifying intraspinal anomalies in patients with idiopathic scoliosis: a 10-year review

Rohit Singhal · Daniel C. Perry · Seema Prasad ·
Neil T. Davidson · Colin E. Bruce

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Abstract

Purpose This study sought to quantify the frequency of previously unidentified spinal cord anomalies identified by routine preoperative magnetic resonance imaging (MRI), in patients planned for surgical scoliosis correction.

Methods Our study group comprised 206 patients with idiopathic scoliosis who underwent deformity correction from 1998 to 2008. Clinical records of all the patients were retrospectively reviewed to ascertain the proportion having a neural abnormality on preoperative MRI scan.

Results Twenty of 206 patients (9.7 %) were diagnosed with an unexpected intraspinal anomaly on routine preoperative MRI. In all cases, a neurosurgical opinion was sought prior to further intervention. Of the 20 patients, 11 underwent a neurosurgical procedure (de-tethering of cord, decompression of Chiari, decompression of syrinx). There was no statistically significant difference between the group of patients who had intrinsic spinal cord anomalies on preoperative MRI and those did not have a cord abnormality with regard to age at presentation, gender, side of dominant curve and degree of curve ($p < 0.05$).

Conclusion The high frequency of spinal cord abnormalities unidentified by preoperative neurological examination, and the frequent need for subsequent neurosurgical intervention, suggests that MRI assessment prior to deformity correction is important in the management of idiopathic scoliosis.

Keywords Idiopathic scoliosis · Intraspinal anomalies · Preoperative MRI

Introduction

Scoliosis is a three-dimensional spinal deformity. There are several commonly recognized causes, which include congenital deformities and neuromuscular disease. However, in children with no outward physical signs of comorbid disease, and those without an identifiable anatomical precipitant on plain radiographs of the spine, the diagnosis of idiopathic scoliosis is reached. Occasionally, such children may have an undisclosed underlying abnormality of the spinal cord, the identification of which might influence further management.

The prevalence of intraspinal anomalies amongst patients with idiopathic scoliosis is uncertain and found to be variable [1]. Consensus regarding the necessity of routine preoperative MRI evaluation to identify such anomalies is lacking. Debate surrounds the clinical significance of subtle MRI abnormalities of the spinal cord, if detected, and the need for intervention. A recent multicentre observational study concluded that there was no difference in the complication rate of scoliosis surgery between patients with normal and abnormal MRI, inferring that preoperative imaging was over-requested and not always required [2].

We report our experience of routine preoperative MRI evaluation in patients undergoing treatment for idiopathic scoliosis.

Methods and material

Routine neurological examination and MRI assessment were undertaken for all patients requiring treatment for

R. Singhal (✉) · D. C. Perry · N. T. Davidson · C. E. Bruce
Department of Orthopaedics, Alder Hey Children's Hospital,
Liverpool L12 2AP, UK
e-mail: singhal.rohit75@gmail.com

S. Prasad
Department of Orthopaedics, Warrington District General
Hospital, Warrington, UK

presumed idiopathic scoliosis as a part of a departmental protocol. Treatment included any intervention (i.e. cast, brace or surgical correction) as determined through discussion amongst the treating clinician(s), the patient and family. A neurosurgical opinion was sought for all patients who were found to have brain stem or cord abnormalities detected by MRI. Any patient found to have a clinical neurological deficit at initial examination was excluded from the study. The neurosurgical team took the decisions regarding the management of the intraspinal anomaly. Interventions for scoliosis were only undertaken after neurosurgical review and subsequent management.

The records of all patients who underwent treatment for presumed idiopathic scoliosis between August 1998 and August 2008 were reviewed. Cases of congenital, neurogenic or syndromic scoliosis and those with incomplete records were excluded. Patients who had a neurological deficit when examined by the orthopaedic team were also excluded. This study therefore included only those patients who (1) presented with deformity of the spine as their primary complaint, (2) had a normal clinical neurological examination when examined by the orthopaedic team, (3) had no congenital vertebral defect on plain radiographs and (4) had scoliosis severe enough to warrant intervention.

The following details were sought—gender, age at MRI evaluation, neurological findings, presence or absence of neural abnormality on MRI scan, type of abnormality if present, neurosurgical procedure, type of scoliosis correction procedure undertaken, postoperative complications and period of follow-up. Patients with an intraspinal anomaly on preoperative MRI evaluation were compared to those without any anomaly with regard to the age at presentation, gender, side of curve and degree of curve.

Statistical analysis

Statistical Package of Social Sciences (SPSS) version 19 (Chicago, Illinois, Inc.) was used. Categorical data were compared using Fisher's exact test and continuous data were compared using Student's *t* test. A *p* value of <0.05 was considered to be significant.

Results

206 patients met the inclusion criteria. Of these, 20 (9.7 %) were detected to have a neural abnormality on routine preoperative MRI scan. The abnormalities detected are shown in Table 1. No statistically significant difference was observed between the patients with neural abnormality compared to those without any abnormality with regard to age at presentation, gender, degree and side of curve (Table 2).

11 (55 %) of the 20 patients who had a neural abnormality on MRI scan underwent a neurosurgical procedure prior to the scoliosis correction procedure. Table 3 shows the details of all 20 patients who were found to have an unexpected anomaly and who were referred for a neurosurgical opinion. Of these 20 patients, 7 (35 %) had subtle neurological signs demonstrated on re-examination, but only after it was known that an MRI abnormality had been identified. In patient 13, biopsy results showed a low-grade astrocytoma of the conus, which was further reviewed and assessed by the oncology team. The patient is still under oncology review, but has been discharged from orthopaedic follow-up following successful instrumentation and fusion.

All the patients were followed up for a minimum period of 24 months. One patient developed a minor serous discharge from the surgical wound in the early postoperative period, which settled with observation and conservative management. This patient also developed rib pain that settled with conservative management. Two patients were

Table 1 Description of neural abnormalities detected on preoperative MRI evaluation

Type of neural abnormality	Number of cases
Isolated syrinx	7
Syrinx with Chiari malformation	4
Isolated Chiari malformation	4
Syrinx with tethered cord	2
Split spinal cord T5 downwards with low-lying conus at the level of L3/L4 disc	1
Intrinsic spinal cord tumour	1
AV fistulae	1
Total	20

Table 2 Comparison between patients with and without neural abnormality on preoperative MRI assessment

Descriptive data	Patients with no neural anomaly (<i>n</i> = 186)	Patients with neural anomaly (<i>n</i> = 20)	<i>p</i> value
Gender (M:F ratio)	35:151 (1:4.3)	5:15 (1:3)	0.56
Average age at presentation (95 % CI)	11.2 years (10.6–11.8)	11.8 years (10.8–12.7)	0.57
Degree of curve (95 % CI)	57.4 (55.1–59.7)	58.0 (51.7–64.3)	0.88
Side of curve (right:left)	145:41 (3.5:1)	4:1	1.0

CI confidence interval

Table 3 Descriptive data on patients who had intraspinal anomalies on preoperative MRI assessment

Patient	Age at presentation (years)	Presenting symptom	Neurological finding	MRI finding	Neurosurgical procedure	Deformity correction procedure	Complication	Follow-up period (years)
1	10	Deformity	None	Syrinx from T10–T12	None	AR with PSF	None	2
2	10	Deformity	Absent abdominal reflexes brisk knee and ankle reflexes bilaterally	Syrinx T11–T12	None	PSF	None	2
3	12	Deformity with pain	None	Chiari 1 malformation	None	AR with PSF	None	2
4	12	Deformity	None	Chiari 1 malformation	None	AR with PSF	None	2
5	14	Deformity	None	Syrinx C2–C4	None	PSF	None	2
6	12	Deformity	None	AV fistula	None	AR with PSF	None	2
7	12	Deformity	None	Chiari 2 malformation	None	AR with PSF	None	2
8	8	Deformity	None	Split spinal cord T4 downwards with conus ends at L3/L4	None	AR with PSF	Residual lumbar curve	3
9	15	Deformity	Asymmetrical lower limb reflexes	Syrinx T10–T11	None	ASF	None	2
10	10	Deformity	Absent abdominal reflex	Extensive syringomyelia throughout the cord with sacral cyst	Division of filum terminale	AR with PSF	None	2
11	12	Deformity	None	Syrinx throughout the cord with conus tethered to L3	Division of filum terminale	AR with PSF	None	2
12	12	Backache	None	Chiari malformation	Chiari decompression	PSF	None	2
13	11	Deformity	Brisk upper and lower limb reflexes, abdominal reflexes asymmetrical	Intrinsic spinal cord tumour	Laminotomy T9–T12 and biopsy	ASF	None	3
14	10	Deformity	Absent abdominal reflex on right side with diminished left side triceps reflex	Syrinx in cervical spine with Chiari malformation	Posterior fossa craniectomy with Chiari decompression	PSF	None	2
15	9	Deformity	Absent abdominal reflexes, left lower limb reflexes diminished, absent upper limb reflexes	Syrinx throughout the spinal cord with Chiari malformation	Chiari decompression	AR with PSF	Wound ooze, rib pain	3
16	14	Deformity and backache	None	Cervical syrinx with Chiari malformation with tethered cord	Division of filum terminale	PSF	None	2

Table 3 continued

Patient	Age at presentation (years)	Presenting symptom	Neurological finding	MRI finding	Neurosurgical procedure	Deformity correction procedure	Complication	Follow-up period (years)
17	10	Deformity	Absent bilateral; knee and right ankle jerk, reduced upper limb reflexes with asymmetrical abdominal reflexes	Chiari 1 malformation with cervical syrinx	Division of filum terminale and Chiari decompression	AR with PSF	Residual curve	3
18	16	Deformity with backache	None	Chiari malformation with syrinx from foramen magnum to thoracic spine	Chiari decompression	PSF	None	2
19	13	Deformity	None	Syrinx C7–L1	Division of filum terminale	PSF	None	2
20	13	Deformity	None	Syrinx in thoracic region	Division of filum terminale	PSF	None	2

left with a small residual lumbar curve, which was well tolerated.

Discussion

This study adds support to the importance of preoperative MRI imaging in identifying unexpected brain stem and spinal cord anomalies during the management of idiopathic scoliosis. The detection rate of abnormalities was surprising (9.7 %), especially given that all of these were deemed initially to have a normal screening neurological examination. Furthermore, a large proportion of the abnormalities detected warranted neurosurgical intervention (11 of 20 individuals). Therefore, in our population, routine preoperative MR imaging appears warranted.

Numerous other studies have discussed the utility of MRI in detecting neural abnormality in patients with idiopathic scoliosis. Studies conducted during the late 1990s unanimously concluded that routine preoperative MRI was an essential screening tool to rule out neural abnormalities in patients presenting with idiopathic scoliosis [3–6]. Each of these studies was small, typically including less than 100 patients. Subsequent larger studies resulted in a shift in opinion, with the suggestion that clinical indicators may be used to predict intraspinal abnormalities in an otherwise seemingly benign idiopathic scoliosis, without the need for MR imaging.

Subtle neurological deficits [7–10] (for example, absent superficial abdominal reflexes) were amongst the earliest indicators and were shown to have a positive correlation with the presence of neural abnormality. However, Rajasekaran et al. [11] demonstrated that 54.5 % of the patients who had MRI neural abnormality had no neurological deficit on preoperative clinical examination. Other

investigators demonstrated an absence of such neurological abnormalities amongst individuals with MRI-proven intraspinal abnormalities [5, 12].

Left-sided thoracic curves have also been suggested to be associated with a higher frequency of neural abnormality in patients with idiopathic scoliosis [1, 12]; however, other studies have failed to corroborate this finding [13]. Others suggest that the clinical predictors of intraspinal lesions include sagittal plane malalignment of spinal contour [2, 11, 12], early-onset scoliosis [1, 3, 11, 12], severe curves in immature individuals [14, 15], double curves [11], pain [1, 12] and male gender [16]. However, no specific indicator appears reliable or reproducible in its predictive value.

The largest of all studies to date was a multicentre observational study that included 923 scoliosis patients, in whom routine preoperative MRI imaging identified 39 [4.2 %] neuro-axis malformations [2]. This study suggested a positive association between juvenile-onset curves or those with a thoracic hyperkyphosis and presence of syrinx on preoperative MRI evaluation, though no such association could be demonstrated for other intraspinal lesions (Chiari malformation or tethered cord). Similarly, no useful predictive information for neural abnormality was gained from the assessment of curve magnitude, curve direction, patient gender, body habitus or stage of maturity (Risser grade). Whilst sagittal malalignment, such as thoracic hyperkyphosis, may have a predictive value, it is difficult to assess, clinically or with plain radiographs, owing to spinal rotation, overlap of thoracic rib cage and failure to obtain true lateral radiographs [17].

Whilst we acknowledge that careful preoperative examination may uncover subtle findings that could predict the presence of MRI abnormalities, this is not universal and the absence of such findings does not guarantee the absence

of MRI findings. Thirteen patients with an unexpected neurological MR finding had a normal neurological examination, including deep tendon reflexes, even on repeat examination following an abnormal MRI. A further seven were found to have a subtle neurological abnormality on a repeat examination, though the examiner was aware of the MRI-detected abnormality at this stage, which is likely to heighten the examiner's ability to elicit subtle abnormalities. Interestingly, of the 11 patients who required neurosurgical treatment, only 4 had clinically apparent neurological findings evident after MRI. These individuals therefore demonstrate that clinical examination is not a wholly sensitive means of detecting significant neurological anomalies.

Twelve (60 %) of the 20 patients were above 11 years of age at presentation and 3 (15 %) of the 20 had a left-sided curve. These results therefore add to the evidence suggesting that clinical signs are poor predictive indicators of neurological abnormalities.

Knowledge of existing intraspinal anomaly prior to scoliosis correction procedures can be invaluable to prevent intraoperative neurological injury, which can be caused by distraction applied to correct the deformity [18]. Additionally, neurosurgical treatment may halt curve progression or even lead to resolution [19].

Our study therefore offers additional evidence, from a single centre, to suggest that a normal neurological examination is a poor predictor of negative MR imaging in idiopathic scoliosis requiring intervention. Awareness of neurological abnormalities is important in the preoperative assessment of scoliosis, to prevent iatrogenic morbidity and ensure the efficacy of the treatment. Given the accessibility, acceptability, reliability, reproducibility and safety of spinal MR imaging, we advocate the consideration of its routine use in all patients undergoing interventions for idiopathic scoliosis.

Conflict of interest None.

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