Are there magnetic resonance imaging-detectable pathologies in idiopathic scoliosis patients?

Victoria GH Stanley

Abstract

Scoliosis may be a spinal manifestation of underlying disease, therefore, imaging plays a very important role in determining the underlying aetiology of so-called ‘idiopathic’ scoliosis. If underlying intraspinal defects go unrecognised and untreated, irreversible neurological deficit can develop.

Magnetic resonance imaging (MRI) is the modality of choice for imaging the spinal canal, albeit controversially. This literature review has been designed to find out whether there are associated MRI-detectable pathologies in idiopathic scoliosis patients. If so, what is the incidence of such abnormalities? And when would MRI evaluations be warranted for idiopathic scoliosis patients?

Twenty studies relating to MRI and scoliosis met the criteria and were used to perform a meta-analysis. The majority of the articles took the view that a non-invasive investigation which does not use ionising radiation and which can reliably exclude such intraspinal occult disease should not be withheld.

Results showed that, in a population of 1398 idiopathic scoliosis patients, MRI detected 226 (16%) related intraspinal pathologies. The most common pathologies were 73 syringomyelias (32%) and 44 Chiari malformations (19%).

In conclusion, until further investigation is conducted into the clinical significance of the intraspinal diseases with idiopathic scoliosis, whole spine MRI evaluations with a variety of imaging planes and pulse sequences are warranted in all idiopathic scoliosis patients, even if it is from a defensive risk management viewpoint.

Introduction

Are there associated magnetic resonance imaging (MRI) detectable pathologies in idiopathic scoliosis patients? Idiopathic scoliosis is the lateral deviation of the spine due to an unknown cause. Scoliosis may be a spinal manifestation of underlying disease and should only be considered idiopathic after all other causes have been ruled out. Although most cases of scoliosis are idiopathic, imaging plays a very important role in determining the underlying aetiology and in monitoring the changes of the deformity that take place with growth.1

Before the advent of MRI, myelography or high-resolution CT studies were performed for the visualisation of intraspinal anomalies in idiopathic scoliosis patients. These techniques provided detailed anatomic information, but they were highly invasive and technically difficult, particularly in larger more complex curves. Also, such studies have recognised risks. High resolution CT involves exposure to ionising radiation and requires the intrathecal introduction of water-soluble contrast material to delineate the spinal cord. Furthermore, it is recognised that these methods have a false negative rate of approximately 3–5% and underestimate the extent of intraspinal pathology, therefore being nonspecific in the information they produce.2

Many studies have been done examining the use of MRI in detecting associated pathologies in what was otherwise thought to be idiopathic scoliosis.3,4,5,6 However, most of this literature is very conflicting. Some studies state that MRI is valuable for detecting underlying anomalies of so-called ‘idiopathic’ scoliosis, therefore preventing surgery-associated neurological risks,7,8 but other studies have stated that the incidence of detecting such abnormalities is low and usually inconsequential as only 10% of adolescents diagnosed with scoliosis have curve progression requiring medical intervention.9 There are also many studies which state that the use of MRI remains controversial.5,8,10,11

To investigate the use of MRI in idiopathic scoliosis further, a literature review was proposed to answer three questions:

1. Are there associated MRI detectable pathologies in idiopathic scoliosis patients?
2. What is the incidence of such abnormalities?
3. When are MRI evaluations warranted for idiopathic scoliosis patients? (Should it be done only when indicated? Or should it be done in all cases when undergoing corrective surgery? Or should it be done in all scoliosis patients?)

Independent variables of this study would include the researcher’s radiographic technique; including scan planes and pulse-sequences used. Also, the researcher’s experimental design; including instrumentation used (MRI scanner field strength) patient sample size and selection processes (curvature size/type) and whether there is the inclusion of neurologically abnormal patients in the study.

Dependent variables include the ability of the MRI images to demonstrate abnormalities and the ability of the radiologist to detect them.

Method

A computerised literature search was carried out to identify all studies that examined the use of MRI in detecting associated pathologies in what was otherwise thought to be idiopathic scoliosis.

Inclusion criteria

Articles should have researched MRI in idiopathic scoliosis...
patients only, and be published in New Zealand within the last 15 years.

Exclusion criteria

Articles were excluded if there was no reported evidence of where results were drawn from, what pathologies were detected, and data pertaining to the frequency of such pathological detections.

Once the study articles were obtained, the radiographic technique and research designs were evaluated in order to moderate the validity and reliability of each article to answer our research question: ‘Are there associated MRI detectable pathologies in idiopathic scoliosis patients?’ according to the literature reviews.

Radiographic technique

Most literature thought it essential to examine the entire spine from brainstem to sacrum. Clear demonstration of the cranio-cervical and lumbo-sacral junctions is vital to allow exact localisation of lesions for the surgeon. All of the studies were therefore classified according to whether they imaged the entire spine, or did not.

Studies were also classified on how thorough they were by evaluating how many imaging techniques were utilised. Specific techniques looked for included the use of sagittal planes, axial planes, coronal planes, T1-weighted images and finally T2-weighted images. This would give an indication as to which studies used a variety of imaging planes and different weighted scans to give the best diagnostic images possible.

Research design

There are several variables to be accounted for in the studies’ research designs, including the type/size of curvatures, field strength of the MR scanner and the patient sample size. To keep results reliable, authors should have strict sampling characteristics for the patient selection to only include idiopathic scoliosis. (There are several types of idiopathic scoliosis: Juvenile, Infantile and Adolescent idiopathic scoliosis depending on the age of onset). Therefore, no patients can have any neurological or clinical symptoms predisposing them to non-idiopathic scoliosis. All scoliosis patients should have undergone a normal physical and neurological examination.

Severe curves, which might require treatment, or could progress to a stage requiring treatment, are usually 40 to 100 degrees, according to Cobb Angle measurement. Patients with severe curves of this size will have a higher frequency of spinal cord abnormalities detected in an MRI scan.

When determining the quality of the images one is trying to obtain, the field strength of the magnet used is a vital element. High field scanners have many advantages over their lower field counterparts. Researchers should utilise super-conducting, high magnetic field strength units, which would equate to 1.5 Tesla or greater.

Studies evaluated in this paper should not lack a proper patient population predisposing them to selection bias. By taking an average across all the studies, a population of 70 patients or more per group was considered to be adequate (1398 patients in total, 20 groups in total = an average of 70 patients per group).

Finally, research design reporting. The researchers must have a clear and definite statement, which is indicative of the question they aim to answer. It has to be obvious to the reader and specifically and effectively answered at the end. The researchers’ analysis and interpretation should relate to the evidence of this research question. The limitations of the research need to be acknowledged by systematically identifying all of the variables, then taking steps to control them.

Results and Discussion

Twenty studies relating to MRI and scoliosis met the criterion and were used to perform a meta-analysis. Each study was then classified according to the predetermined coding characteristics to evaluate its validity and reliability. A total validity score was then calculated for each study and was treated as an observation used to examine and compare the articles to find which one had the most reliable results. The average validity rating across the studies was 6.65. Thirteen of the 20 articles had above average ratings.

Validity ranged from two to 10. This difference can be explained by the fact that each study had used different types of idiopathic scoliosis (ie. infantile, juvenile and adolescent), different imaging instrumentation and techniques and there were also large variations in study sizes. Also, if the article didn’t acknowledge information pertaining to a specific code it was considered non-compliance, and the article was given a negative rating.

Studies with the highest validity ratings were Cheng at 10, Chan, Shen and Schwend all with nine. All patients had normal preoperative neurological examinations, and only three abnormalities were detected (4% detection). Of these three abnormalities, none were considered clinically significant. All surgical patients underwent instrumentation and fusion without incident. However Shen had poor radiographic technique, as they did not image the lower lumbar spine, which is known for exhibiting a high incidence of intraspinal pathologies.

Schwend found 14 of 95 patients (21%) to have an intraspinal pathology, four of these pathologies necessitated neurosurgical intervention. The study included more than one type of idiopathic scoliosis: juvenile and adolescent. It also had a very mixed group of ages (1 to 28 years), curve sizes (11 to 95 degrees) and neurological statuses with several patients having a false negative finding. This may have been due to the fact that patients were not given a physical or neurological evaluation prior to commencement of the study. Their high validity rating of nine can be justified by the fact that the radiographic technique was excellent, utilising all three planes on a high frequency MR scanner.

Cheng and Chan both had excellent research design because...
of their stating experimental variables and taking steps to control them. Chan et al. had a detection rate of 89% in severe curves (40 degrees +) and only 7% in small/moderate curves (10–55 degrees). No neurological examinations on the patients were confirmed. The research question only related to muscular pathological processes and didn’t observe intraspinal anomalies. However, they rated the second highest on the validity chart, with scores of nine for Group 1 and eight for Group 2. This was due to their radiographic technique being of a high standard. They imaged the entire spine with all three planes in a T2 weighting with a high field strength scanner.

Cheng et al. carried out a study in patients with adolescent idiopathic scoliosis of different clinical severities using whole-spine magnetic resonance imaging and found that the prevalence of spinal canal anomalies increased with an increase in the curve severity. The research design included three groups: the randomly selected control group, moderate sized curvature group and the severe curvature group. The third group in this research article had a validity rating of 10, the highest obtained in this review. Therefore, we can say that Cheng et al. had the most reliable results. They concluded that MRI might have an important diagnostic and predictive value, which may help in the management of adolescent idiopathic scoliosis (AIS).

Pathological detection was 3% in normal subjects, 4% in subjects with moderate curves and 45% detection in subjects with severe scoliosis. The results of this study performed by Cheng et al. showed a significant number of patients with AIS had underlying structural and functional neurologic abnormalities. This result is different from the observation of Shen, and Winter whose research found a lower incidence of spinal canal anomalies in patients with AIS. In my view, their research design report was poor compared to that of Cheng. However, the latter did not provide any information on selection, curvature size or experimental variables.

Inoue et al. and Bradford et al. had the worst validity scores in the review. Neither accumulated any points under radiographic technique at all, and scored poorly on research design reporting. In spite of Inoue et al.’s detection rate of 13% and Bradford et al.’s impressive pathological detection rate of 52% their results are questionable given that they included ‘genetic idiopathic scoliosis’ patients and ‘congenital idiopathic scoliosis’ patients, both of which are not truly classified as idiopathic as there is some understanding of the medical history or background of the patient’s curvature. Bradford et al. had a large age range, but Inoue et al. failed to report the age ranges of patients included in their study. Inoue et al. used the lowest field strength scanner (0.5 Tesla) out of all the articles evaluated. Neither study, confirmed the use of neurological examinations prior to MRI.

Overall, the majority of studies had poor radiographic technique practices. T1 weighted sequences are less sensitive than T2 weighted images in detecting certain types of intraspinal pathology. Yet only 43% of the articles carried out T2 weighted imaging techniques. Koch et al. found that axial slices were indispensable to allow accurate planning of the operative approach, and suggested that they should be obtained in all cases amenable to operation. Of the studies evaluated, 52% utilised axial planes and, surprisingly, only 35% utilised coronal planes. One would assume that the latter would be an obvious choice in idiopathic scoliosis imaging, as coronal MRI of the entire spine would allow monitoring of scoliosis in the sagittal plane (via Cobb angle measurements), which can reveal relevant clinical data without radiation exposure. Only 65% of the studies conducted entire spine imaging.

Many of the studies evaluated in this paper had a research design that failed to report a proper patient population; only 30% of the studies had a population greater than 70 patients. This predisposed them to selection bias as only 35% of studies had adequate patient selection processes. This was obvious in the sense that only 48% of studies included neurologically normal patients and 39% of studies had patients with curvatures greater than 40 degrees. 48% of the studies used high field strength MR scanners of 1.5 Telsa or greater. However, the studies research questions and design reports were fairly good, having results of 57% and 63% respectively.

As demonstrated in Figure 2, the most common MR abnormalities detected were syringomyelias (32%) and Chiari malformations (19%) occurring in isolation or combination. In most instances these findings were deemed minor, considered asymptomatic, and corrective neurosurgical intervention was not performed. However, in children, asymptomatic Chiari malformation’s including tonsilar ectopias are common and frequently scoliosis has been the initial finding in patients who have these neurological abnormalities. Some studies think that if MRI is not done in all idiopathic scoliosis cases, such abnormalities will be missed.

**Conclusion**

This literature review has been designed to find out if there are associated MRI demonstrable pathologies in idiopathic scoliosis patients and if so, what the incidence of such abnormalities is and when are MRI evaluations warranted for idiopathic scoliosis patients? Some of the articles reviewed pointed out the high cost and low availability of MRI. However, the costs caused by neurological deficit due to spinal fusing in the presence of intraspinal pathology may be higher. The majority of the articles took the view that MRI is a non-invasive modality which does not use ionising radiation, it can also reliably exclude relevant intraspinal occult diseases and should therefore not be withheld.

It is not entirely understood whether the detected abnormalities on MRI are relevant to the formation of a scoliosis curvature, or whether such abnormalities are likely to develop, progressing to a stage where they can cause neurological dysfunction. For Chiari-1 malformations with well-defined neurological deficits, surgical decompression is considered necessary as regression/stabilisation of a scoliosis deformity with Cobb Angles less than 40 degrees after decompression have been reported. It has also been suggested that early surgical decompression of a syrinx may be effective in reversing early scoliosis. However, whether there is a higher risk of neurological damage during surgical correction.
and instrumentation of scoliosis patients with syringomyelia has been controversial as their clinical significance is not entirely understood. Further research would need to be conducted to prove those undetected and untreated underlying intraspinal defects such as syringomyelia and Chiari malformations cause irreversible neurological deficit.

In conclusion, in a population of 1398 idiopathic scoliosis patients, MRI detected 226 (16%) related intraspinal pathologies. Such pathologies included 73 syringomyelia (32%), 44 Chiari malformations (19%), 23 tethered cords (10%), 14 tonsilar ectopias (6%) and 13 spinal cord tumours (6%). In my view, this detection rate is high, therefore the use of a non-invasive modality such as MRI is more than justified particularly in the light of it not using ionising radiation and its ability to reliably exclude intraspinal occult diseases. Until further investigation is conducted into the clinical significance of such intraspinal diseases with idiopathic scoliosis, whole spine MRI evaluations with a variety of imaging planes and pulse sequences are warranted in all idiopathic scoliosis patients – even if only from a defensive risk management viewpoint.

References