Scoliosis Rates in Symptomatic Patients as Demonstrated With Weight-Bearing or Supine MR Imaging

Manuel S. Vogt, OMS IV; John W. Gilbert, MD; Robert Windsor, MD; Gregory E. Mick, DO; Gay B. Richardson, MD; Benjamin B. Storey, MD; and Stephanie L. Herder, MD

From the University of Pikeville–Kentucky College of Osteopathic Medicine (Student Doctor Vogt) and Physicians Services, PSC, in Lexington, Kentucky (Drs Gilbert, Windsor, Mick, Richardson, Storey, and Herder).

Financial Disclosures: None reported.

Support: This study was self-funded by Physician Services, PSC.

Address correspondence to John W. Gilbert, MD, Kentucky Pain Care, PO Box 22430, Lexington, KY 40522-2430.

E-mail: correspondence@kentuckypaincare.com

Submitted February 22, 2012; revision received September 18, 2012; accepted November 17, 2012.

Context: In the United States an estimated 6 million persons are affected by scoliosis, which is characterized by a 3-dimensional deformity of the spine that involves a curvature in the sagittal, frontal, and transverse planes.

Objective: To determine the rates of scoliosis in patients with spine-related pain unassociated with cancer, as demonstrated by magnetic resonance (MR) images obtained with patients in either a weight-bearing or a supine position.

Methods: The authors conducted a retrospective review of MR images obtained during a 2-year period in patients referred because of symptoms of radiculopathy or other spine-related pain unassociated with cancer and unresolved after conservative treatment. Images were obtained either with the patient supine or with the patient in a weight-bearing, seated position, and all images were reviewed by a neuroimaging physician. Scoliosis was assessed according to the Cobb angle method.

Results: A total of 1982 MR images from 1486 patients were reviewed. Of those, 986 images in 761 patients were obtained with a low–field-strength (0.3-T) MR imager with the patient supine, and 996 images in 725 patients were obtained with a mid–field-strength (0.6-T) MR imager with the patient in a weight-bearing, seated position. Scoliosis (dextroscoliosis, levoscoliosis, or both) was identified in 958 MR images (48.3%), of which 779 (78.2%) were obtained with patients in a weight-bearing position and 179 (18.2%) were obtained with patients in a supine position.

Conclusion: The scoliosis rate was lower in the supine MR imaging group than in the weight-bearing MR imaging group. Scoliosis rates may be affected by the position in which the patient is examined, with the possibility that the weight-bearing position differentially exposes scoliosis, compared with the supine position.

J Am Osteopath Assoc. 2013;113(3):210-214

In the United States an estimated 6 million persons are affected by scoliosis, typically characterized by a 3-dimensional deformity of the spine that involves a curvature in the sagittal, frontal, and transverse planes.[1,2] Scoliosis can be described as functional (ie, with a reversible, muscular cause) or structural (due to unequal growth).[3] The Cobb angle[4] can be used to measure curvature of the spine, as described in the "Methods" section. When viewed from the rear, lateral spinal curvatures are classified as either *dextroscoliosis* (convex to the right) or *levoscoliosis* (convex to the left). The purpose of the present study was to use magnetic resonance (MR) imaging, performed with patients in a weight-bearing or a supine position, to determine the rate of scoliosis in patients with symptoms of radiculopathy or other spine-related pain unassociated with cancer and unresolved after conservative treatment.

Methods

We retrospectively reviewed serial MR images obtained during a 2-year period (from January 1, 2006, through December 31, 2007) in patients with spine-related pain, all of whom provided written consent for publication of de-identified personal health information. All patients had been referred by a physician to our urban, private, multispecialty neuroscience practice in Kentucky in 2006 or 2007 because of radiculopathy or other chronic spine-related pain syndrome unassociated with cancer. All patients had also completed a regimen of conservative treatment, which included nonsteroidal anti-inflammatory drugs together with physical therapy, osteopathic manipulative treatment, or chiropractic therapy. As appropriate, patients had received muscle relaxants, opioids, or sleep-enhancing medications. In each patient included in the present study, symptoms had remained unresolved after conservative treatment.

During the period when the MR imaging was completed, 3 of our 5 clinic locations were equipped with a mid–field-strength (0.6-T) MR imager (Upright MRI; Fonar; Melville, New York) that allowed imaging of patients in a weight-bearing, seated position. The other 2 clinics were equipped with a low–field-strength (0.3-T) MR imager (Airis II; Hitachi Medical Systems, Twinsburg, Ohio) that allowed imaging of patients in a supine position.

All of our MR imaging machines were accredited by the American College of Radiology. A high-definition computer workstation using Radworks technology (GE Healthcare, Buckinghamshire, England) was available at each office facility; offices were linked by secure intranet-encrypted T lines so that images could be reviewed by the offsite neuroimaging physician.

Each patient had selected a clinic location for MR imaging examination on the basis of personal preference. On the day of the examination, each patient had completed a comprehensive MR imaging intake form and questionnaire, which asked for medical history information, including questions about the onset, duration, and radiation of pain (with pain categories including burning, sharp, dull, and throbbing); bowel or bladder dysfunction; and numbness or weakness. The MR imaging technologists at each location had reviewed these data with the radiologist or neuroimaging physician for potential contraindications to imaging; common contraindications in patients included the presence of a pacemaker, spinal cord stimulator, deep brain stimulator, metal shavings in eyes, certain aneurysm chips, or other MR-incompatible devices. Images were not taken if imaging was contraindicated. Reports were incorporated into patient records.

Each image was assessed by the neuroimaging physician (J.W.G.) using the Cobb method.[4] Using this method, one measures the curvature of the spine by choosing the most tilted vertebrae above and below the apex of the curve; the *Cobb angle* is defined as the angle between intersecting lines drawn perpendicular to the vertical axis of the top vertebra, taken at the superior (top) surface and the bottom of the bottom vertebra. The Cobb angle provides a quantitative, objective standard for diagnosing idiopathic scoliosis and is used as a criterion for deciding treatments according to current recommendations.[5] A diagnosis of scoliosis was confirmed when the Cobb angle was greater than 10°. For all images, scoliosis was identified as dextroscoliosis, levoscoliosis, or both.

Cobb angle data from all radiologic, neuroimaging, and neuroradiologic reports were gathered retrospectively in a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, Washington) and reviewed by the medical student (M.S.V.) and the neuroimaging physician (J.W.G.). No statistical analyses were performed.

Results

A total of 1982 serial MR images obtained in 1486 symptomatic patients were reviewed. No records were excluded from the study. Of the 1982 images, 986 were obtained in 761 patients with the patient supine (48.9% female patients [482 images], aged 9-94 years; 51.1% male patients [504 images], aged 24-104 years; 225 participants were imaged multiple times), and 996 images were obtained in 725 patients with the patient imaged in a seated, weight-bearing position (48.9% female patients, aged 18-86 years [497 images]; 50.1% male patients, aged 13-82 years [499 images]; 270 patients were imaged multiple times).

Scoliosis was identified in 958 MR images (48.3%), of which 179 (18%) were taken with the patients in the supine position and 779 (72%) were taken with the patients in the weight-bearing position (*Table*).

Supine MR Imaging

Of the 986 images obtained with the patient supine, 179 images (18.2%; 92 in female and 87 in male patients) showed a form of scoliosis. Of these, 45 images (25.1%; 21 in female and 24 in male patients) displayed dextroscoliosis, 113 (63.1%; 60 in female and 53 in male patients) displayed levoscoliosis, and 21 (11.7%; 11 in female and 10 in male patients) displayed components of both.

Weight-Bearing MR Imaging

Of the 996 MR images obtained with the patient in a weight-bearing position, 779 (78.2%; 431 in female and 348 in male patients) displayed a form of scoliosis. Of these, 262 images (33.6%; 145 in female and 117 in male patients) displayed dextroscoliosis, 437 (56.1%; 233 in female and 204 in male patients) displayed levoscoliosis, and 80 (10.3%; 53 in female patients and 27 in male patients) displayed components of both.

Comment

Reports of the scoliosis prevalence among asymptomatic adults vary.[6-14] Schwab et al[6] reported a scoliosis rate of 68% in a study of spine radiographs in asymptomatic adults older than 60 years (mean age, 70.5 years); radiographs were obtained with patients in a conventional, forward-standing (weight-bearing) position, and scoliosis was defined as a Cobb angle greater than 10°. Schwab et al attributed the high rate in their study in part to the advanced age of study participants compared with those in previous studies.[7-14] In a retrospective study of dual-energy x-ray absorptiometry scans obtained with patients in a supine position, Kebaish et al[7] identified scoliosis (Cobb angle >11°) in 8.8% of 3185 adults aged 40 years or older. In a report of a study of 3000 college-aged women, Francis[8] noted that 11.8% had a visible degree of scoliosis as observed from behind with the participant standing in a conventional, forward-facing position. In a study that used multiple MR imager brands and field strengths, Anwar et al[9] found scoliosis on MR images to be underreported. Among 1299 patients in that study, the prevalence of adult lumbar scoliosis was 19.9%; this prevalence increased significantly ($P<.001$) by age group, ranging from 9.1% in adults aged 45 years or younger to 38.9% in those older than 60 years. Other studies conducted in the 1980s found scoliosis rates in adult populations ranging from 2% to 32%.[10-14]

The literature includes some reports on the prevalence of pain in populations with known scoliosis, espe-

Table.
Scoliosis Diagnoses Determined From Supine and From Weight-Bearing Magnetic Resonance Images of Male and Female Patients With Spine-Related Pain (N=1486)

	Magnetic Resonance Images, No. (%)[a]					
	Supine (n=986 images)[b]			Weight-Bearing (n=996 images)[c]		
Diagnosis	**Male**	**Female**	**Total**	**Male**	**Female**	**Total**
Dextroscoliosis	24 (2.4)	21 (2.1)	45 (4.6)	117 (11.7)	145 (14.6)	262 (26.3)
Levoscoliosis	53 (5.4)	60 (6.1)	113 (11.5)	204 (20.5)	233 (23.4)	437 (43.9)
Dextroscoliosis + Levoscoliosis	10 (1.0)	11 (1.1)	21 (2.1)	27 (2.7)	53 (5.3)	80 (8.0)
Total Scoliosis	**87 (8.8)**	**92 (9.3)**	**179 (18.2)**	**348 (34.9)**	**431 (43.3)**	**779 (78.2)**

[a] Percentages may not total 100 because of rounding.
[b] Two hundred twenty-five participants were imaged multiple times.
[c] Two hundred seventy patients were imaged multiple times.

cially in adolescents with idiopathic scoliosis. Compared with nonscoliotic controls, most adolescents with idiopathic scoliosis show spinal function at or near normal levels but have an increased prevalence of pain, with increased severity of pain in some cases.[15] Back pain was shown to affect three-quarters of adolescents with idiopathic scoliosis.[16] In a study of 43,630 pupils in elementary and junior high schools, the prevalence of back pain more than doubled in students with a diagnosis of scoliosis compared with students without scoliosis.[17]

Our findings showed a disparity between images taken in the weight-bearing position and those taken in the supine position, with scoliosis rates of 78.2% vs 18.2%, respectively. This disparity raises the possibility that the weight-bearing position, compared with the supine position, may differentially expose scoliosis. The higher rate of scoliosis observed with MR imaging in the weight-bearing position is consistent with rate differences between weight-bearing MR imaging and supine MR imaging that we have reported elsewhere for both disk protrusion and spinal stenosis; we noted disk protrusion[18] and spinal stenosis[19] rates of 73.3% and 56.7%, respectively, for weight-bearing MR imaging vs 50.1% and 38.5%, respectively, for supine MR imaging.

Several aspects of the experimental design of this study limit the extent of the conclusions that can be drawn from the data. First, the patients attended our private practice specialty clinic and underwent imaging because they had unresolved spine-related pain. Therefore, our findings are not representative of individuals in our practice with asymptomatic scoliosis or of those in the general population. Second, it was impossible to blind the person interpreting the images because of image characteristics specific to the MR imaging equipment. Images originating from different locations were identifiable by the type of imager used because of differences between the supine and the weight-bearing MR imaging technologies in software packages, image format, and field of view. Third, because all images were evaluated by 1 person, we could not measure the reliability of his diagnoses against another clinician's impression. Fourth, patients imaged in a weight-bearing position may be more likely to have pain that could result in muscle spasm, which in turn could affect spinal curvature.[20] Furthermore, the magnetic field strength differences between the mid–field-strength imagers with weight-bearing positioning and low–field-strength imagers with supine positioning produce inherent differences between the images. To compare the technologies, a prospective study design should ideally be used. Unfortunately, in our private practice, economics precluded this approach, because payers are unwilling to cover supine and weight-bearing imaging in the same patient at the same point in time.

Conclusion

The rates of scoliosis detected with MR imaging in this large retrospective study were 18.2% for imaging in the supine position and 78.2% for imaging in a weight-bearing position. Our results warrant future studies to determine whether weight-bearing MR imaging, as opposed to supine MR imaging, differentially exposes scoliosis.

References

1. National Scoliosis Foundation. Information and support. National Scoliosis Foundation website. http://www.scoliosis.org/info.php. Accessed January 30, 2012.
2. Good CR. The genetic basis of adolescent idiopathic scoliosis. *J Spinal Res Found*. 2009;4(1):13-17.
3. Solberg G, Gur V, Adar E. *Postural Disorders and Musculoskeletal Dysfunction: Diagnosis, Prevention and Treatment*. New York, NY: Elsevier Health Science; 2008:100-101.
4. Cobb RJ. Outline for the study of scoliosis. *AAOS Instr Course Lect*. 1948;5:261-75.
5. Negrini S, Aulisa AG, Aulisa L, et al. 2011 SOSORT guidelines: orthopaedic and rehabilitation treatment of idiopathic scoliosis during growth. *Scoliosis*. 2012;7(1):3.
6. Schwab F, Dubey A, Gamez L, et al. Adult scoliosis: prevalence, SF-36, and nutritional parameters in an elderly volunteer population. *Spine (Phila Pa 1976)*. 2005;30(9):1082-1085.
7. Kebaish KM, Neubauer PR, Voros GD, Khoshnevisan MA. Scoliosis in adults aged forty years and older: prevalence and relationship to age, race, and gender. *Spine (Phila Pa 1976)*. 2011;36(9):731-736.
8. Francis RS. Scoliosis screening of 3,000 college-aged women: the Utah study— phase 2. *Phys Ther*. 1988:68(10):1513-1516.
9. Anwar Z, Zan E, Gujar SK, et al. Adult lumbar scoliosis: underreported on lumbar MR scans. *AJNR Am J Neuroradiol*. 2010;31(5):832-837.
10. Carter OD, Haynes SG. Prevalence rates for scoliosis in US adults: results from the first National Health and Nutrition Examination Survey. *Int J Epidemiol*. 1987;16(4):537-544.
11. Grubb SA, Lipscomb HJ, Coonrad RW. Degenerative adult onset scoliosis. *Spine (Phila Pa 1976)*. 1988;13(3):241-245.
12. Kostuik JP, Bentivoglio J. The incidence of low back pain in adult scoliosis. *Spine (Phila Pa 1976)*. 1981;6(3):268-273.
13. Rinsky LA, Gamble JG. Adolescent idiopathic scoliosis. *West J Med*. 1988;148(2):182-191.
14. Robin GC, Span Y, Steinberg R, Makin M, Menczel J. Scoliosis in the elderly: a follow-up study. *Spine (Phila Pa 1976)*. 1982;7(4):355-359.
15. Asher MA, Burton DC. Adolescent idiopathic scoliosis: natural history and long term treatment effects. *Scoliosis*. 2006;1(1):2. doi:10.1186/1748-7161-1-2.
16. Landman Z, Oswald T, Sanders J, Diab M. Prevalence and predictors of pain in surgical treatment of adolescent idiopathic scoliosis. *Spine (Phila Pa 1976)*. 2011;36(10):825-829.
17. Sato T, Hirano T, Ito T, et al. Back pain in adolescents with idiopathic scoliosis: epidemiological study for 43,630 pupils in Niigata City, Japan. *Eur Spine J*. 2011;20(2):274-279.
18. Gilbert JW, Martin JC, Wheeler GR, et al. Lumbar disk protrusion rates of symptomatic patients using magnetic resonance imaging. *J Manipulative Physiol Ther*. 2010;33(8):626-629.
19. Gilbert JW, Martin JC, Wheeler GR, et al. Lumbar stenosis rates in symptomatic patients using weight-bearing and recumbent magnetic resonance imaging. *J Manipulative Physiol Ther*. 2011;34(8):557-561.
20. Gilbert JW, Wheeler GR, Storey BB, et al. Lumbar magnetic resonance imaging hypolordosis in symptomatic patients: association with paraspinal muscle spasms. *J Chiropractic Med*. 2009;8(3):95-100.