A First-Year DPT Student’s Perspectives on a Cadaver with Scoliosis

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ABSTRACT

Study Design: Single subject observational case report. Background: Scoliosis is a condition commonly managed by physical therapists (PTs) in most settings. Patient management may include surgical correction, which requires PTs to be knowledgeable of the type of surgery and implications. Recent orthopedic research has found that disease type may alter vertebral anatomy, indicating the need for further consideration of the surgical technique used. Case Description: Measurements of vertebral anatomy of a human cadaver were obtained by bisection of the vertebra, then compared with measurements from magnetic resonance (MR) images in previously reported orthopedic studies. The purpose of this study was to explore and combine the literature review with examination of a human specimen to gain a deeper understanding of scoliotic anatomy in order to enhance future clinical practice as well as to attempt to identify the underlying condition that led to scoliosis and other impairments in the cadaver. Outcomes: This study led to a hypothesis of etiology of scoliosis in the cadaver by comparison of physical measurements to existing studies and synthesis of existing research. Cadaveric measurements generally matched corresponding measurements of idiopathic scoliosis as described in previous studies. Analysis of the global abnormalities of the cadaver led to a clinically applicable understanding of the end-stage of life presentation of scoliosis and the necessity of management of this condition. Conclusion: According to research, the spinal column in patients with scoliosis may differ anatomically based on disease. This study, by improving one student’s knowledge of scoliosis, raised the question of whether PTs should base management decisions of scoliosis on etiology due to the anatomical differences. The opportunistic approach to this study shows the importance of students’ willingness to explore disease processes that may be present in the cadaver population within the anatomy laboratory.

Background

Scoliosis is defined as a 3-dimensional deformity of the spine, including a frontal plane curvature of more than 10 degrees (Cobb angle > 10). Scoliosis is often found in patients receiving physical therapy. Scoliosis can have many different etiologies. Regardless of the etiology, scoliosis can present with a multitude of impairments that are either directly or indirectly treated or otherwise managed by the physical therapist (PT). Severe cases of scoliosis (Cobb angle greater than 50°) indicate corrective surgery that usually involves a pedicle screw insertion. Physical therapists may be involved in the developmental stages of a patient with scoliosis, preoperative treatment, or postoperative rehabilitation. Therefore, it is important for the physical therapist to have a clear understanding of the normal and abnormal anatomy of the spinal column and the effects of scoliosis on function as well as an understanding of the implications of surgical procedures in order to best manage the patient. Most research that is done on surgical and rehabilitative practices regarding scoliosis has focused on patients with adolescent idiopathic scoliosis (AIS) since this type is most commonly seen. Other classifications of scoliosis are osteogenic, neurogenic, and neuromuscular.

Idiopathic scoliosis is known as adolescent
idiopathic scoliosis (AIS) and is most commonly seen with 80-90% of all cases of scoliosis classified as such.6,9 Although the cause is unknown, there are many theories as to its mechanism of action including a genetic component. AIS can be managed by bracing and ultimately surgery.6 Neuromuscular scoliosis is characterized by an irregular curvature caused by abnormal biomechanics of muscle and nerve. The curve progression is more severe and progresses more quickly than the curvature in patients with AIS. Progression of the curvature can continue into adulthood. Neuromuscular scoliosis can be caused by neuropathic means (paralysis) or myopathic means (muscular dystrophy [MD], poliomyelitis).7

Research has shown that specific anatomical parameters can be used to determine the type of scoliosis present. Some parameters are typical of scoliosis while others characterize certain conditions. The study performed by Jae-Young et al, chose four pathologies to represent the different categories of scoliosis: idiopathic, neuropathic, neuromuscular, and osteogenic.4 Generally, the inner and outer vertebral pedicle widths were wider on the convex side, the chord length and pedicle length were greater on the concave side, and the transverse pedicle angle was higher on the concave side with parameters being more significant at the apical vertebra in each pathology.4 These parameters were helpful in retrospectively identifying the type of scoliosis in the cadaver that was observed in the current study.

Adolescent Idiopathic Scoliosis

Adolescent idiopathic scoliosis was characterized by the typical parameters mentioned above as well as a thoracic or thoracolumbar curve with an S-form curve. One possible explanation as to the cause of AIS is “altered cerebral cortical/subcortical function or hemispherical dominance.”6 This can lead to biomechanical changes of the musculature stabilizing the spine. This can also cause an unbalanced growth rate of the anterior and posterior vertebral bodies.8 The anterior body grows at a faster rate than the posterior body, forming a wedge that may lead to a collapse or lateral shift of the vertebral column. This growth dysfunction may arise at different stages of development. The authors cited a study that showed that many patients with AIS present with asymmetry in the ventral pons and medulla.8 This can lead to denervation of paraspinal musculature causing a lateral deviation to one side.8 The spinal musculature on the affected (convex) side therefore has an increased number of type I muscle fibers.8 Curve progression in AIS may be due to the further failure of paraspinal musculature and/or ligaments that stabilize the spine. This may be caused directly by the denervation of the paraspinal muscles or indirectly due to the strain of the lateral deviation and abnormal forces. This curve progression usually occurs at a rate of 1-2° per year.8 This fact may be helpful in identifying the general onset of the curvature in the cadaver of interest, which can aid in the identification of the disease type leading to the scoliosis.

Neuromuscular/neuropathic

According to Abul-Kasim, et al, there are three strong indicators that can be used to distinguish neuromuscular/neuropathic scoliosis from idiopathic scoliosis: a curve length greater than 8 vertebrae, a non-S form curve, and a lower-end vertebra at the level of L4 or L5 are characteristics of neuromuscular/neuropathic scoliosis and are rarely seen in idiopathic scoliosis.1 “Neuromuscular scoliosis is more severe and more progressive, and is associated with more morbidity. Factors that contribute to this spinal deformity include asymmetric paraplegia, imbalance of mechanical forces, intraspinal and congenital anomalies of the spine, altered sensory feedback, and
abnormal posture via central pathways.2"

Deviation in patients with CP is not due to a bony deformity as is theorized in AIS. Scoliosis in the patient with CP is unique in that the rotation is incomplete or atypical: the vertebral body is rotated toward the concave side while the spinous process is rotated toward the convex side.1 One theory is that this is caused by the spastic state of the paraspinal musculature that is characteristic of CP resisting rotation of the vertebral column.4 “Left-sided curves, rapidly progressive curves, and severe curves are more likely to have a neurologic or neuromuscular etiology rather than idiopathic scoliosis.2” The curve will also be smaller than the curve in idiopathic scoliosis and the last vertebra may be lower.1

Osteogenic

Congenital (osteogenic) scoliosis may be easier to recognize due to the nature of the abnormality; the deformity will have been present at birth and the patient may present with comorbidities and pain, unlike AIS where patients are usually asymptomatic. The curve in congenital/osteogenic scoliosis can be an S-form although it is more likely to be a C-form curve.1

Emerging literature in the field of orthopedic surgery is showing that the disease has varying anatomical presentations. MRI studies were conducted and showed that pedicle widths along with other vertebral measurements differed between disease types, indicating weaker vertebral components in some disease types than others. This suggests that corrective surgical techniques and placement of screws, for example, may depend on the disease type. In other words, not all scoliosis “looks” the same and should not be treated the same way. The purpose of the current study was to investigate the spinal anatomy in a scoliotic cadaver-patient to replicate measurements and techniques from MRI and gross measurements conducted in surgical studies; furthermore, this study presented the question of whether disease type warrants further consideration in how scoliosis is managed by physical therapists.

Case Description

This case study was reviewed and approved by the Mercer University Internal Review Board. The subject of this case study was a female human cadaver who died at 92 years of age. General observation of the cadaver revealed marked lateral deformity of the thoracic and lumbar spine as well as a noticeably increased kyphotic curve of the thoracic spine (Fig.1A-C), rendering the cadaver unable to lie flat in either the supine or prone position. Upon further investigation the cadaver presented with a completely flattened right lung that was approximately a third of the dimensions of the left lung and adhered to the chest wall. Axial muscle groups presented asymmetrically with the musculature on the lumbar concave side (right) presenting with major atrophy (see Figs. 1D and 2B). Right external oblique muscles were atrophied to the point that only the muscle belly was present and adhered to the underlying musculature. The right latissimus dorsi and lower trapezius presented in the same way. Interestingly, there appeared to be excess hip flexor musculature bilaterally. A discrete muscle directly posterior to the rectus femoris and anterior to the iliopsoas traveled the course of the iliopsoas, however, this muscle had independent origins and insertions. A separate exploratory paper is being conducted on this finding.

Gross measurements and observations were taken, patterned after Abul-Kasim, et al1: curve length, curve form, location of curve, and location of lower-end vertebra. The cadaver presented with an S-form curve with a right thoracic spine curve and a left lumbar spine curve. The lumbar spine was the more severe curve with a vertebral length of six...
Table 1

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<th>Gross Cadaveric Scoliotic Measurements</th>
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<td>Rotation of Body</td>
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<td>Curve Shape</td>
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<tr>
<td>Curve Length</td>
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<tr>
<td>Lower-End Vertebra</td>
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<tr>
<td>Cobb Angle</td>
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<td>Apex of Curve</td>
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Based on article by Abul-Kasim, et al. Results most closely correlate with idiopathic scoliosis.

Table 2

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<th>Intra-vertebral Measurements of L2</th>
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<td>PWI (mm)</td>
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Based on article by Jae-Young, et al. Results most closely correlate with idiopathic scoliosis.

Figure 1

A) Right thoracic curve (hidden by amount of kyphosis) and B) left lumbar curve as well as C) thoracic kyphotic curve D) Asymmetrical extensor musculature
Figure 2


Figure 3

Inferior surface of superior half of L2 vertebra. Notice A) asymmetry of transverse processes, B) calcification due to right-side collapse.
and a Cobb angle of 48°. The Cobb angle of the thoracic curve was 40°. The apex of the main curve was L2 and the lower-end vertebra was L5.

The next set of measurements were patterned after those by Jae-Young, et al. A transverse plane bissection through the midline of L2 was accomplished with a manual hand saw in order to replicate the images gathered through MRI in the previous study. This allowed all of the intra-vertebral measurements taken using the MRI images to be achieved in the lab. These dimensions consisted of chord length (CL): length of the long axis of the pedicle from tip of pedicle to border of anterior body, inner pedicle width (PWI): the width of the trabecular bone measured from just inside the cortical edges, outer pedicle width (PWO): the width of the pedicle measured just outside the cortical edges, pedicle length (PL): measured from the joining of the pedicle and the transverse process and the posterior border of the vertebral body, and the transverse pedicle angle (TPA): the angle between the axis of the pedicle and the axis of the vertebral body. Dimensions were measured utilizing a digital caliper that was calibrated between each measurement and the TPA was measured using a small universal goniometer. Each reported measurement was an average of three trials. These dimensions were measured on the concave and convex sides in order to identify trends and compare them to the results of the previous study. The cadaveric measurements are identified in Table 2.

Outcomes

In regard to the formation of an etiological hypothesis, this study accomplished this goal. Upon comparison of measurements to the two studies, the cadaveric dimensions most closely correlated with those representing patients with idiopathic scoliosis. The trends that led to this conclusion include CL and TPA being greater on the concave side and PWI and PL being greater on the convex side, all of which are shown to be statistically significant (P<.05) indicators of AIS according to literature. The greater PWO on the concave side did not match the dimensions characterizing AIS in the literature, however, the authors hypothesize that given the age and apparent longevity of her condition, the expected increased calcification can account for the greater PWO on the approximated side. Having a thoracolumbar S form spinal curve showed to be a statistically significant (P=.035) indicator of having idiopathic scoliosis.

Observation of the L2 vertebra revealed obvious bilateral asymmetry (Fig. 3). The right (concave) side of the vertebra presented with osteophytic build-up covered with fatty deposits and little muscular and ligamentous attachments. Excess calcification was also present along the body of the right side. The right transverse process was much smaller than the left and nearly disintegrated upon extraction. This is concurrent with Wolfe’s Law and the Physical Stress Theory, which essentially states that bone will react to stress or lack of stress. Osteophytic build-up is a result of approximation of bone due to right-sided spinal column collapse. The collapse renders the musculature on the right side mechanically disadvantaged and atrophy occurs, leading to replacement of healthy tissue with adipose tissue and weakening of the bone due to lack of tension.

Discussion

This experience afforded the opportunity for a novel DPT student to utilize cadaver lab resources and explore professional literature to enhance their knowledge of the anatomy and physiology relating to scoliosis. This study also highlights a new exploratory dissection technique that mimics an MR image and can be utilized in the anatomy lab by DPT students. Specifically for this case
study, these parameters were retrospectively used to identify the pathology leading to the extreme case of scoliosis in the cadaver. The evidence found in literature along with the findings of this dissection led to other questions. Should the unique anatomical parameters present in scoliotic vertebrae of different etiologies be used in developing more accurate and effective rehabilitation and surgical techniques? For example, patients with CP have shown to have vertebra that are not completely rotated due to spasticity and, therefore, are more vulnerable to neural canal penetration during a surgical procedure. For PTs, this information means that we should be aware of the novel literature of other fields so that we can be effective advocates for our patients and make sure they are being managed with the best care. This also raises the question as to whether these anatomical differences should have an effect on how we manage patients with different disease types that present with scoliosis as well.

Students should take advantage of the opportunity to utilize their anatomy lab and resources in order to further their educational experience and hopefully lead to new discoveries that will benefit the profession of Physical Therapy. With gains being made in the areas of direct access and establishing PTs as the practitioner of choice, it is vital that we take the initiative to further our knowledge within our scope of practice while being cognizant of the medical community as a whole in order to provide the highest level of care to our patients.

References


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