Scheuermann's Kyphosis in Adolescents and Adults: Diagnosis and Management

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Abstract

Scheuermann's thoracic kyphosis is a structural deformity classically characterized by anterior wedging of 5 degrees or more of three adjacent thoracic vertebral bodies. Secondary radiographic findings of Schmorl's nodes, endplate narrowing, and irregular endplates confirm the diagnosis. The etiology remains unclear. Adolescents typically present to medical attention because of cosmetic deformity; adults more commonly present because of increased pain. The indications for treatment are similar to those for other spinal deformities, namely, progression of the deformity, pain, neurologic compromise, and cosmesis. The adolescent with pain associated with Scheuermann's kyphosis usually responds to physical therapy and a short course of anti-inflammatory medications. Bracing has been shown to be effective in controlling a progressive curve in the adolescent patient. For the adult who presents with pain, the early mainstays of treatment are physical therapy, anti-inflammatory medications, and behavioral modification. In patients, either adolescent or adult, with a progressive deformity, refractory pain, or neurologic deficit, surgical correction of the deformity may be indicated. Surgical correction should not exceed 50% of the initial deformity. Distally, instrumentation should be extended beyond the end vertebral body to the first lordotic disk to prevent the development of distal junctional kyphosis.

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In 1920, Scheuermann first described the entity of structural thoracic kyphosis that now bears his name. The clinical condition of Scheuermann's kyphosis has widely variable presentations that do not necessarily correlate with the radiographic findings; evaluation of a lateral thoracic radiograph is necessary to establish the diagnosis. Sørensen[1] defined the radiographic diagnosis of Scheuermann's kyphosis on the basis of anterior wedging of 5 degrees or more of at least three adjacent vertebral bodies. (This definition is helpful in differentiating Scheuermann's kyphosis from familial round-back deformity.) Adolescents with Scheuermann's kyphosis typically present to medical attention on the urging of family or teachers who are concerned about the cosmetic deformity. Adults who have been living with the cosmetic deformity for long periods of time usually seek medical attention because of increased pain. Although Scheuermann's kyphosis has been well described in terms of clinical presentation and radiographic findings, the etiology remains largely unknown, and the indications for treatment continue to be debated.

Normal Thoracic Kyphosis

Unlike scoliosis, in which any lateral deviation of the spine in the coronal plane can be deemed abnormal, the sagittal alignment of the thoracic spine displays a range of normal that is dynamic. Thoracic kyphosis typically increases throughout life. Fon et al[2] determined that kyphosis in children under the age of 10 years averages 20.88 degrees (SD, 7.85) for boys and 23.87 degrees (SD, 6.67) for girls; in adolescents up to age 19, kyphosis averages 25.11 degrees (SD, 8.16) in boys and 26.00 degrees (SD, 7.43) in girls. The slightly greater kyphotic deviation in females increases after age 40. In women aged 50 through 59, mean kyphosis measures 40.71 degrees (SD, 9.88); in age-matched men, it is 33.00 degrees (SD, 6.46). While the values are still debated, the Scoliosis Research Society has stated that the accepted range of nor-

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mal thoracic kyphosis for a growing adolescent is between 20 and 40 degrees, and that any degree of kyphosis at the thoracolumbar or lumbar area of the spine should be considered abnormal.[3]

Epidemiology and Pathogenesis of Scheuermann's Kyphosis

In 1964, Sørensen[1] reported a prevalence of Scheuermann's kyphosis of 0.4% to 8.3%. Of the five studies that Sørensen cited, those by Wassman in 1951 and Bonne in 1955 reported a prevalence of 0.4%. While these represented the larger series, they perhaps contained inherent bias in that they included only men who had been rejected for military service because of their deformity. Realizing this potential bias, both investigators estimated that the total prevalence of Scheuermann's kyphosis was between 4% and 8%, which is more in line with the findings of other investigators. In a subsequent review of 1,384 cadaveric specimens, Scoles et al[4] reported a prevalence of 7.4%.

It is generally considered that the prevalence of Scheuermann's kyphosis is approximately equal in males and females. In Sørensen's review,[1] 58% of the patients were male, and 42% were female. There are, however, widely divergent reports on relative prevalence between the sexes. Bradford[3] reported a female-male ratio of 2:1 for the prevalence of Scheuermann's kyphosis, while Murray et al[5] reported a 2.1-times higher prevalence in males.

The age of onset of Scheuermann's kyphosis is difficult to establish. Sørensen[1] described a Scheuermann's prodrome in patients who have a "lax, asthenic posture from the age of approximately 4 to 8 years, and [in whom] within a few years a real fixed kyphosis has developed." Radiographic findings consistent with Scheuermann's kyphosis are not visible until the age of 12 to 13, corresponding with the onset of puberty. Therefore, adolescent girls typically evidence the radiographic findings before adolescent boys.

The pathogenesis of Scheuermann's kyphosis has yet to be elucidated, although many theories have been proposed. Scheuermann's initial description included a hypothesis that avascular necrosis of the ring apophysis leads to premature cessation of growth anteriorly, which results in wedging of the vertebral body. Schmorl postulated that herniations of disk material through the vertebral endplates (which now bear his name) lead to a loss of disk height and anterior wedging of the vertebral body.[6] Subsequent studies disproved these early theories, but have not yet established a cause.

An underlying genetic factor has been suggested. Halal et al[7] reported in 1978 on five families who demonstrated an autosomal dominant mode of inheritance with high penetrance but variable expression. Skogland et al[8] reported on 62 girls aged 9 to 18 years whose mean height was 2.5 SDs above average; 18 had thoracic kyphosis greater than 40 degrees, and 11 had additional vertebral abnormalities consistent with Scheuermann's disease. Ascani et al supported a similar correlation of Scheuermann's kyphosis with height and also demonstrated increased levels of growth hormone.[6]

Although the anatomic and histologic findings in Scheuermann's kyphosis are well established, the cause-and-effect relationships are less clear. Gross anatomic findings, such as a thickened anterior longitudinal ligament, narrowed vertebral disks, and wedged vertebral bodies, are consistent findings.[2,9] Histologic abnormalities of the cartilaginous endplate have also been described. The ratio of collagen to proteoglycan in the matrix of the endplate is below normal in patients with Scheuermann's kyphosis. The relative decrease in collagen is postulated to result in an alteration in the ossification of the endplate and thus altered vertical growth of the vertebral body.[6]

It has also been postulated that osteoporosis may be an etiologic factor in the development of Scheuermann's kyphosis. Bradford et al[10] prospectively studied 12 patients with Scheuermann's kyphosis with an extensive osteoporosis workup and iliac crest biopsy. While their study did not demonstrate cause and effect, it did show that some patients with Scheuermann's kyphosis have a mild form of osteoporosis, and dietary analysis demonstrated some deficiency in calcium intake. It was hypothesized by the investigators that the osteoporosis may be transient, presenting early in the course of the disease before it becomes radiographically evident. Gilsanz et al[11] subsequently reported on 20 adolescent patients with Scheuermann's kyphosis aged 12 to 18. No evidence of osteoporosis could be demonstrated when compared with controls as measured by quantitative computed tomography. However, this does not necessarily contradict the theory that early osteoporosis may be an etiologic factor.

Mechanical factors have also been postulated in the development of Scheuermann's kyphosis. Scheuermann initially noted a high incidence of kyphosis in industrial workers. The role of mechanical factors is also supported in part by the success of bracing.[12] What

remains unclear in the mechanical theory is whether the histologic endplate changes predispose to the development of pathologic kyphosis or are secondary.

Evaluation

The indications for the treatment of patients with Scheuermann's kyphosis can be grouped in five general categories: pain, progression of deformity, neurologic compromise, cardiopulmonary compromise, and cosmesis.

For appropriate evaluation, a detailed history and physical examination must be combined with radiographic evaluation to document the patient's status in each category.

History and Physical Examination

The adolescent typically comes to medical attention for different reasons than the adult. Adolescents often present on the urging of parents, teachers, or friends, primarily for cosmetic or postural complaints. Pain is more commonly the chief complaint of adults. The issues in the history and physical examination, however, are similar for both groups.

If pain exists, its location, exacerbating features, and severity should be documented. Typically, pain is located just distal to the apex of the deformity in a paraspinal location. If the pain pattern is atypical, particularly in an adolescent, other causes for the pain must be ruled out. In the adolescent, when pain or discomfort is reported, it is most often activity-related and presents as either pain in the typical area associated with Scheuermann's kyphosis or simply early fatigue. The symptoms are most commonly relieved immediately with rest and usually are not activity-limiting. In adults, pain is a much more common presenting complaint. Hyperlordosis distal to the thoracic deformity and subsequent degenerative disk and facet arthropathy predispose adults to low back pain; the typical pain over the deformity may coexist or predominate. Sørensen[1] reported that pain was the presenting complaint in over 50% of the 103 patients in his initial review. Other authors have noted the occurrence of pain in 20% to 60% of their patients.[3]

Scheuermann's disease may also exist in a variant form (pseudo-Scheuermann's disease), in which the predominant deformity is at the thoracolumbar or even the lumbar region of the spine. Pain is typically concordant with these variant locations, and the cosmetic deformities at these alternate locations may not be as severe.[13]

Progression of the deformity is an additional indication for treatment of patients with Scheuermann's kyphosis. Careful attention to the history of the curve is essential. The deformity may have been ignored or considered to merely represent poor posture; this combined with typical adolescent hesitancy and self-consciousness may result in a delay in diagnosis. The patient's perception that the deformity is increasing and previous radiographic evaluation can provide concrete evidence of progression of the deformity. Similar issues should be addressed in the adult, in whom radiographic confirmation can more often be obtained.

Cord compression secondary to Scheuermann's kyphosis is rare, but when present may mandate surgical treatment. The history of onset of the neurologic compromise is quite variable, ranging from acute onset of unilateral radiculopathy to insidious onset of spastic paraplegia. The underlying cause is that the spinal cord is draped over the apex of the deformity. A short-segment severe deformity is generally considered to be at highest risk, but this is not fully supported in the literature. Lonstein et al[14] demonstrated an average kyphosis of 95 degrees in a mixed population of patients with neurologic compromise, while Ryan and Taylor[15] showed an average kyphosis of only 54 degrees in three patients with Scheuermann's kyphosis. Patients with Scheuermann's kyphosis may also present with extradural cysts or acute thoracic disk herniations, which may be exacerbated by the underlying deformity and may cause neurologic compromise.

Cardiopulmonary complaints are extremely rare on initial presentation of patients with Scheuermann's kyphosis. Sørensen[1] reported that chest wall abnormalities had no negative effect on cardiopulmonary function. However, Murray et al[5] documented restrictive pulmonary disease in patients with kyphosis measuring greater than 100 degrees, with the apex of the curve in the upper thoracic region.

Cosmetic issues related to the curve should also be addressed with the patient. These concerns should not be underestimated as the driving force that initially brings the patient to medical attention. However, when cosmesis is an isolated indication for treatment, particularly surgical intervention, caution should be exercised.

The physical examination is important in documenting the findings of Scheuermann's kyphosis (Fig. 1). Even in adolescents, the sagittal deformity is fairly rigid on hyperextension, whereas in the patient with postural kyphosis, the deformity is more correctable. Both types of deformity may be rigid in

Fig. 1 Adolescent with kyphotic deformity. (Courtesy of David S. Bradford, MD, San Francisco.)

the adult. Having the patient bend forward and viewing the deformity from the side is the best way to delineate the kyphosis. Typically, the cervical spine and the lumbar spine display increased lordosis, while the overall sagittal and coronal balance is well maintained. The shoulder girdles are often rotated anteriorly; the combination of this characteristic with the cervical lordosis can produce a stooped and awkward appearance. The arms and legs will appear relatively long compared with the shortened trunk. The lower extremity should also be evaluated, particularly for hamstring tightness and underlying neurologic compromise. On forward bending, the patient with Scheuermann's kyphosis will have an "A-frame" deformity with a more limited area of involvement than the patient with familial round-back deformity.

Radiologic Evaluation

Routine radiographic studies obtained for evaluation of the patient with Scheuermann's kyphosis should include anteroposterior and lateral radiographs of the entire spine on long films and a hyperextension lateral image of the thoracic spine. The lateral radiograph should be obtained with the patient standing with knees and hips fully extended and arms flexed forward to 90 degrees. The patient should be looking straight forward. The lateral radiograph will document the typical changes of Scheuermann's kyphosis, such as Schmorl's nodes, disk-space narrowing, irregular endplates, and vertebral wedging.

Both the vertebral wedging and the kyphosis should be measured by the Cobb technique. For measuring the kyphosis, the end vertebral bodies, which are the last vertebral bodies tilted into the kyphotic deformity, should be selected. The angle between the distal endplates of these end vertebral bodies is the kyphotic angle. When evaluating serial radiographs to document true progression, care should be taken to ensure that the same end vertebral bodies are being used. The angle between the endplates of individual vertebral bodies can be measured to assess for vertebral wedging. Wedging of at least 5 degrees of three or more successive vertebral bodies is essential to the diagnosis of Scheuermann's kyphosis.

Variations of Scheuermann's kyphosis do exist, and the diagnosis of Scheuermann's kyphosis may be expanded to allow for the presence of a wider spectrum of the disease. Bradford[3] has stated that the presence of one wedged vertebral body suffices for the diagnosis of Scheuermann's kyphosis. Patients who present with irregular endplate changes, disk-space narrowing, and Schmorl's nodes without vertebral wedging may have another variation of Scheuermann's kyphosis, as may patients with fixed kyphosis but no other typical radiographic findings.

The lateral radiograph should also be used to evaluate other associated conditions, such as hyperlordosis of the lumbar spine, spondylolisthesis, and degenerative changes in the lumbar spine. The anteroposterior radiograph is used to assess the coronal balance of the spine as well as the presence of scoliosis, which is associated with Scheuermann's kyphosis in approximately a third of all patients.

To assess the flexibility of the kyphosis, a lateral radiograph in hyperextension may be obtained. The same vertebral endplates used to assess the standing lateral kyphosis can be selected for the hyperextension lateral view.

Radiography is the most helpful tool in eliminating other elements in the differential diagnosis and in making the diagnosis of Scheuermann's kyphosis. In both adolescents and adults, postural kyphosis is the most common entity in the differential diagnosis. Postural kyphosis is an increase in the thoracic kyphosis of as much as 60 degrees. Radiographic findings typical of Scheuermann's kyphosis should not be found. In the adolescent, the kyphotic angle should be entirely correctable on hyperextension radiographs.

The presence of congenital kyphosis must be ruled out, particularly in the adolescent. If an anterior bar is present, Scheuermann's kyphosis is effectively ruled out. In the adult, other causes of fixed thoracic kyphosis also exist: ankylosing spondylitis, multiple healed compression fractures, tumor, infection, tuberculosis, and postlaminectomy kyphosis. Computed tomography, magnetic resonance (MR) imaging, and myelography may be helpful adjunctive studies to complete the evaluation of the kyphotic deformity.

Natural History

The natural history of Scheuermann's kyphosis is difficult to discern. It is generally agreed that patients with mild deformities may have few clinical sequelae. Those patients who come to medical attention typically do so because of concern about deformity, pain, cosmesis, or (rarely) neurologic symptoms. Back pain and fatigue in the adolescent may improve with skeletal maturity. Back pain in the adult patient with Scheuermann's kyphosis is typically secondary to spondylosis associated with the deformity and is quite often refractory to nonoperative care. Paajaanen et al[16] reported that 55% of the disks in young adults with Scheuermann's kyphosis were abnormal on MR imaging. This rate was five times that in asymptomatic controls.

Murray et al[5] reported on the natural history and long-term follow-up of Scheuermann's kyphosis in 1993. They followed up 67 patients who had a mean kyphotic angle of 71 degrees for an average of 32 years and compared them with age-matched controls. Patients with Scheuermann's kyphosis rated their back pain as more intense and localized in the thoracic spine. They had less demanding jobs on average and less extension of the thoracic spine compared with controls. However, both groups were similar in terms of the level of education, the number of days absent from work, social limitations, use of medications for back pain, and level of recreational activities. The patients in their series also reported little preoccupation with physical appearance. In regard to pulmonary function, those patients with kyphotic curves greater than 100 degrees had a higher incidence of restrictive lung disease.

Other authors have encountered more ominous results. Bradford[17] reported the incidence of severe pain over the thoracic spine in 50% of his patients, with an increased incidence of pain when the kyphosis was centered over the upper lumbar spine. Similarly, Lowe[18] reported severe deformity and back pain as common sequelae in adults with untreated adolescent Scheuermann's kyphosis.

In summary, there is a wide variation in the natural history in patients with Scheuermann's kyphosis. There appears to be a subset of patients with refractory symptoms that warrant the increased risk associated with more aggressive treatments, such as bracing and surgical management.

Treatment

Treatment for patients with symptomatic Scheuermann's kyphosis ranges from observation to anterior and posterior reconstructive surgery. The recommended treatment should be tailored to the individual patient on the basis of the severity of the curve and its consequent symptoms.

Anti-inflammatory Medications

Anti-inflammatory medications can be a useful short-term adjunct to nonoperative care of the adolescent. They may also be considered for longer-term use for the adult patient with low back pain associated with spondylosis.

Exercise

The use of exercise—specifically, extension or postural exercises—has never been demonstrated to improve or halt progression of fixed Scheuermann's kyphosis. However, a thoracic extension program combined with an aerobic exercise program may improve physical conditioning and ameliorate associated pain. In the adult patient with lumbar spondylosis, spinal stabilization or even an aggressive flexion program may be added to the regimen to help manage low back pain.

Brace Treatment

Brace treatment of Scheuermann's kyphosis is typically reserved for the adolescent patient with growth remaining and thus potential for correction of the kyphosis. The indications for instituting brace treatment vary. Sachs et al[12] used 45 degrees as a threshold for initiating treatment.

The brace can be a Milwaukee-style brace, with a neck ring and anterior and posterior uprights connecting to a pelvic girdle. The occiput should be padded off of the neck ring, and there should be pads in the posterior uprights overlying the apex of the kyphosis. Accessory pads can be added over the apex of the scoliotic deformity, should one coexist. The rods are straightened and the pads are adjusted as correction is obtained. Other styles of braces are also available.

When a patient is fitted with a customized Milwaukee brace, a lateral radiograph is obtained to con-

firm proper fit of the brace as well as the degree of correction. The patient should then return to the clinic in 3 to 4 weeks to again ensure proper brace fitting. Lateral radiographs should be obtained at 4- to 6-month intervals thereafter. During bracing, physical therapy may be initiated, including pelvic-tilt exercises to reduce lumbar lordosis as well as a thoracic extension program. The brace should be sequentially adjusted to maximize correction.

After correction has been stabilized and maximized and as skeletal maturity approaches, a weaning process from the brace can begin. Lateral radiographs should be obtained during the weaning process, and any early loss of correction should be addressed by slowing the weaning process.

Bracing can be expected to provide up to 50% correction of the deformity while the brace is in place, with a gradual loss of correction over time. Sachs et al[12] demonstrated that of 120 patients followed up for more than 5 years after discontinuation of the brace, 69% still had improvement of 3 degrees or more from the initial radiograph. Montgomery and Erwin[19] demonstrated similar findings in 21 patients treated with the Milwaukee brace. The initial 21-degree improvement while in the brace had decreased to only 6 degrees at latest follow-up. However, Sachs et al found that when the presenting kyphosis was 74 degrees or more, brace treatment failed in almost one third of cases, necessitating surgical correction.

The role of bracing in the skeletally mature patient with Scheuermann's kyphosis is less clear. Bradford et al[20] reported in 1974 that skeletal maturity is not necessarily a contraindication to Milwaukee-brace treatment and that partial correction of the kyphosis could sometimes be obtained. However, bracing in the adult is often poorly tolerated; perhaps its best niche is in the patient with severe refractory pain due to the kyphosis or lumbar spondylosis who is nevertheless not a surgical candidate.

Surgical Treatment

The operative indications for patients with Scheuermann's kyphosis are similar to those for patients with other types of deformities: progression of the deformity, pain associated with the deformity, neurologic compromise, and cosmesis. An adolescent with Scheuermann's kyphosis with a curve of 75 degrees or more despite appropriate bracing may be an operative candidate. An adult with Scheuermann's kyphosis may become a surgical candidate when severe refractory pain develops secondary to the deformity, which is generally of at least 60 degrees. Neurologic compromise can also become a surgical indication in both adolescents and adults. The perceived cosmetic benefit of surgery cannot be underestimated in dealing with either adult or adolescent patients.

The goal of operative treatment of Scheuermann's kyphosis is to safely obtain a solid arthrodesis throughout the length of the kyphosis with correction of the kyphotic deformity. This can be obtained with a posterior-only approach, an anterior-only approach, or a combined anterior-posterior approach (Fig. 2).

The anterior-only approach, as described by Kostuik,[21] is an anterior-interbody fusion and anterior instrumentation with a Harrington distraction system augmented by postoperative bracing. While the author's results in 36 patients were good, with reduction of the mean preoperative deformity of 75.5 degrees to an average of 60 degrees at follow-up, the anterior instrumented approach is not as widely used for managing Scheuermann's kyphosis.

The posterior-only approach has both advantages and limitations. It offers decreased blood loss and surgical time and avoids the risks associated with a thoracotomy. Reported disadvantages include a higher rate of pseudarthrosis and less correction. The posterior-only approach remains the recommended approach for patients with a flexible deformity that corrects on hyperextension to less than 50 degrees.[22] For more severe deformities, its use may be extended with the addition of segmental fixation and posterior facetectomy.

The anterior-posterior procedure is reserved for patients with more rigid deformities (typically 75 degrees or more) that do not correct to less than 50 degrees on a hyperextension lateral view. Recently, the combined procedure has been more commonly performed at one operative sitting; however, some authors still advocate a staged anterior-posterior procedure. The anterior approach may be performed either open or thoracoscopically. The anterior approach is typically performed on the right to avoid the great vessels. If a concomitant coronal deformity is present, the approach should be directed at the convexity of the deformity. If a left-sided approach is planned, preoperative MR imaging is recommended to assess the location of the great vessels, which, if located posteriorly, can obstruct a safe approach to the thoracic spine.

The open approach is facilitated by resecting a rib, which is later used in performing the arthrodesis. The rib level resected is that corresponding to the most cephalad level of the planned arthrodesis. Care should be taken when planning this approach, however. Radiographs

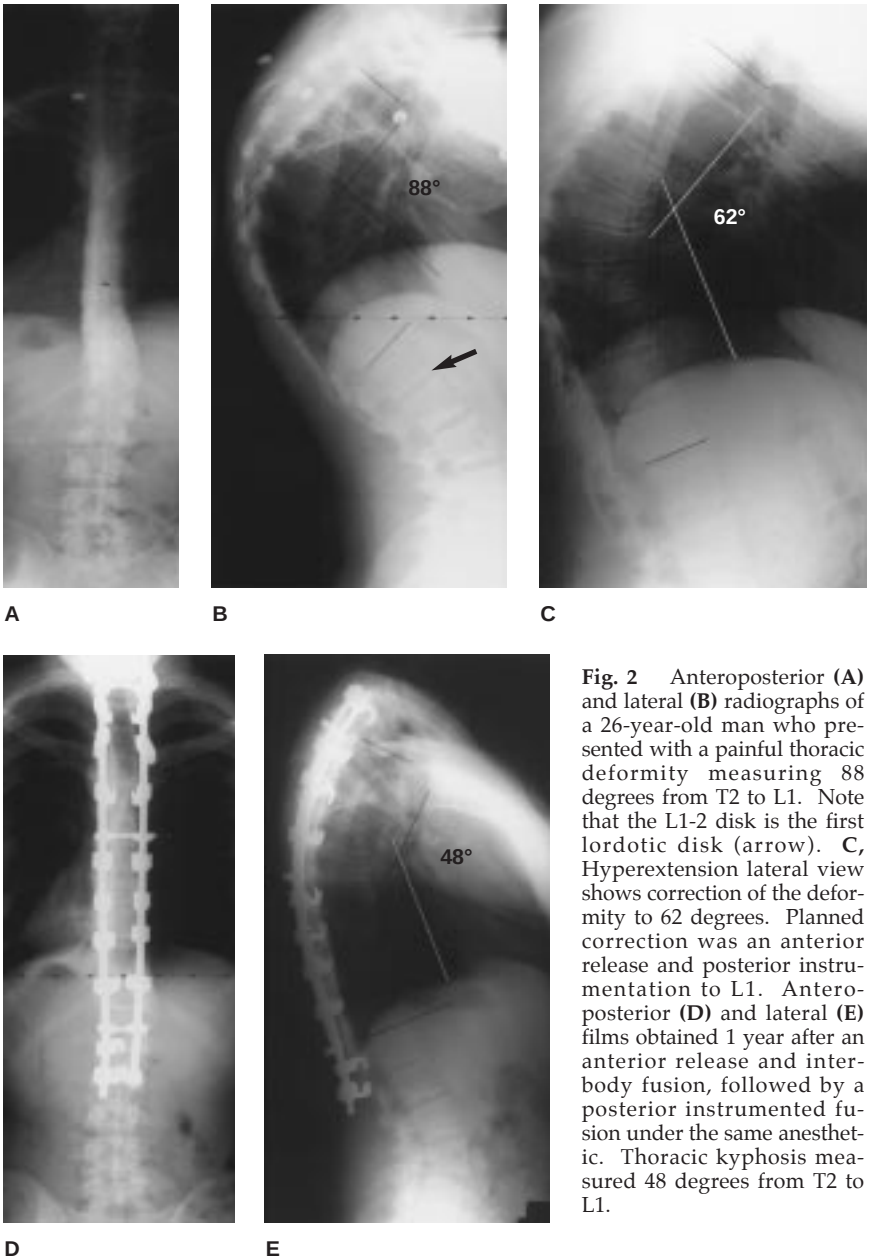

Fig. 2 Anteroposterior **(A)** and lateral **(B)** radiographs of a 26-year-old man who presented with a painful thoracic deformity measuring 88 degrees from T2 to L1. Note that the L1-2 disk is the first lordotic disk (arrow). **C,** Hyperextension lateral view shows correction of the deformity to 62 degrees. Planned correction was an anterior release and posterior instrumentation to L1. Anteroposterior **(D)** and lateral **(E)** films obtained 1 year after an anterior release and interbody fusion, followed by a posterior instrumented fusion under the same anesthetic. Thoracic kyphosis measured 48 degrees from T2 to L1.

should be reviewed preoperatively to evaluate the angle of the thoracic ribs to the thoracic spine and thereby to identify which rib should be resected to facilitate the exposure. An anterior release and interbody fusion is performed on all levels that are wedged or have a narrowed disk space. A full anterior release is performed, including removal of the entire disk back to the posterior longitudinal ligament as well as resection of the anterior longitudinal ligament.

The surgeon has two options for performing the interbody fusion technique. Structural rib graft may be placed in each disk space, providing support to the anterior column. Alternatively, a trough can be created in the lateral aspect of the vertebral bodies, which is subsequently filled with morseled bone. This creates a column of graft that will not dislodge during posterior manipulation. The posterior procedure can then be performed under the same anesthetic or can be staged. If the procedure is staged, the patient can be mobilized out of bed during the interim to prevent complications associated with long-term bed rest. Use of the Harrington compression system for the posterior instrumentation is well documented in the literature. However, segmental posterior systems (e.g., Cotrel-Dubousset, Texas Scottish-Rite Hospital, and Isola) have evolved to provide improved correction, often obviating the need for postoperative bracing or casting.

Posterior correction of the kyphotic deformity can be performed by one of two instrumentation techniques: the compression technique and the leverage technique. The compression technique is a four-rod construct in which two upper rods are connected to two distal rods by domino devices. Compression is then applied over the apex of the deformity through the domino devices. This has the net effect of shortening the posterior column and reducing the kyphotic deformity.

The leverage technique is performed by using two long posterior rods with the planned correction prebent into the rods. The rods are attached either proximally or distally by a claw technique. Additional segmental hooks are then progressively attached to the rod as they are levered toward the spine, thus reducing the deformity. This technique has the advantage of decreased hardware bulk over the apex of the deformity.

Regardless of which technique is employed, the compression technique or the leverage technique,

great care should be taking in choosing fusion levels. The sagittal balance should be assessed preoperatively by dropping a plumb line from the C7 vertebral body and measuring the distance from the sacral promontory to the plumb line. If the plumb line falls anterior to the promontory, the balance is positive. Sagittal balance is often negative in patients with severe Scheuermann's kyphosis and is typically exacerbated by surgical correction of the kyphosis.

Overcorrection may lead to worsening of sagittal balance and an increased incidence of proximal kyphosis. Proximally, the fusion should be extended to the end vertebra (i.e., the most cephalad vertebral body that remains angulated into the concavity of the deformity). Distally, the instrumentation should be extended beyond the end vertebral body to the first lordotic disk beyond the transitional zone. The overall correction should not exceed 50% of the initial deformity or less than 40 degrees. Adherence to these guidelines, which were proposed by Lowe and Kasten,[23] should reduce the risk for proximal and distal junctional kyphosis.

Summary

Scheuermann's thoracic kyphosis is a structural deformity classically characterized by anterior wedging of at least 5 degrees of three adjacent thoracic vertebral bodies. Adolescents typically present to medical attention with concerns about cosmetic deformity; adults more commonly present because of increased pain. Progression of the deformity, pain, neurologic compromise, and cosmesis are the issues that typically dictate treatment options. In the adolescent, pain associated with a kyphotic deformity will usually respond to physical therapy and anti-inflammatory medications; a progressive curve may be responsive to bracing. In the adolescent or adult patient with a progressive deformity, refractory pain, or neurologic deficit, surgical correction of the deformity may be indicated. Surgical approaches include a posterior-only approach and a combined anterior-posterior approach. Meticulous attention to surgical technique is mandatory; avoiding overcorrection and junctional kyphosis by the appropriate selection of fusion levels is of particular importance.

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