Evidence Based Medicine
Analysis of Scheuermann Kyphosis

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Objective. To provide current concepts for the rational evaluation and treatment of Scheuermann kyphosis supported by EBM.

Summary of Background Data. The literature concerning etiology, natural history, and treatment of Scheuermann disease has mixed views and recommendations, most of which are not strongly supported with levels of evidence.

Methods. A thorough database search was performed in order to obtain the best current information and levels of evidence on etiology, natural history, and treatment options for Scheuermann kyphosis based on EBM criteria.

Results and Conclusion. Scheuermann kyphosis is the most common cause of hyperkyphosis in adolescence. Its true etiology remains unknown, but there appears to be a strong genetic as well as an environmental contribution. The kyphotic deformity is frequently attributed to “poor posture” resulting in delayed diagnosis, and treatment indications remain debated because the natural history has not been clearly defined. When recognized early in adolescence with progressive kyphosis, bracing treatment will usually result in modest correction of the deformity. Symptomatic adolescents with severe deformity have not demonstrated significant deformity correction following surgical intervention; however, clinical outcomes data are not yet available, and the studies available do not have strong levels of evidence.

Key words: kyphosis, ring apophysis, Scheuermann kyphosis, TLSO brace, vertebral body wedging. Spine 2007; 32:S115–S119

Surgeons have become increasingly interested in evidence-based medicine (EBM) in recent years. Most surgeons would agree that comprehensive, readily available information helps surgeons make better clinical choices. Assessment of study design and determination of a “level of evidence” is a quantifiable way to rate the quality of the surgical literature. This manuscript reviews the recent English orthopedic literature dealing with the etiology, natural history, and treatment of Scheuermann kyphosis and provides an assessment of the evidence supporting current care of this condition. A database search was made between the years 1986 and 2006 un-

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The manuscript submitted does not contain information about medical device(s)/drug(s).
No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.
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Etiology

At present, the etiology of Scheuermann kyphosis is unknown. It has been noted by several investigators that there appears to be an increased familial incidence of Scheuermann kyphosis. A recent study by Damborg et al reviewed 35,000 twins to establish a cohort of symptomatic twins with Scheuermann kyphosis recorded in the Danish twin registry between 1931 and 1982. They found an overall prevalence of Scheuermann kyphosis to be 2.8% with a prevalence of 2.1% among women and 3.6% among men. The pairwise concordance for monozygotic twins was 0.19 compared with 0.07 for dizygotic twins. The probandwise concordance was 0.31 for monozygotic twins and 0.07 for dizygotic twins. Hereditability was 74%. These findings indicate a major genetic contribution to the etiology of “Scheuermann Disease,” “Scheuermann kyphosis,” “natural history of,” “etiology of,” “nonoperative treatment of,” and “operative treatment of.” Databases searched included: Cochrane Database, PubMed, and Medline. Twenty-five journal articles were found. Eight of the articles were based on case reports or opinions alone.

Scheuermann, in 1920, described a rigid kyphosis of the thoracic or thoracolumbar spine occurring in adolescents. Two different curve patterns have been described in Scheuermann kyphosis. The thoracic pattern is the most common and is associated with a nonstructural hyperlordosis of the lumbar and cervical spine. The thoracolumbar pattern is uncommon but is thought to be the most likely to progress in adulthood. However, this conclusion is based on expert opinion only. Postural kyphosis is readily differentiated from Scheuermann kyphosis radiographically because of the presence of a uniformly rounded kyphosis that is nonstructural, and the absence of wedging of vertebral bodies and disc degeneration. The onset of Scheuermann kyphosis usually appears just before puberty, after ossification of the ring apophysis, as a structural kyphotic deformity of the thoracic or thoracolumbar spine. The condition characterized by vertebral body wedging, vertebral endplate irregularity, diminished anterior vertebral growth, and premature disc degeneration is the most common cause of kyphosis in the pediatric population today. Its reported incidence ranges from 1% to 8% of the general population, although its true incidence is probably understated since it is often either missed or attributed to poor posture. The prevalence of Scheuermann kyphosis is approximately equal in males and females.
Scheuermann kyphosis with a smaller environmental component.

The histopathologic findings in Scheuermann kyphosis have been the subject of investigation in recent years. Disorganized enchondral ossification similar to Blount’s disease, a reduction in collagen, and an increase in mucopolysaccharides in the endplate, is noted in patients with Scheuermann kyphosis.15,16 Paajaaen et al noted degeneration of the discs on MRIs in half of young patients with Scheuermann kyphosis as opposed to 10% of asymptomatic controls.11 Whether these changes are primary or related to abnormal mechanical loading of the kyphotic spine is speculation. With brace treatment, other investigators have noted thickening of the anterior longitudinal ligament and partial reversal of the vertebral wedging, lending credence to mechanical theories of pathogenesis.12–14 It is probable that several factors are important in the pathogenesis of Scheuermann kyphosis, some genetic and some environmental, further investigation will be needed before any definite conclusions can be reached.

Natural History

A study by Murray et al8 detailed a long-term follow-up of 67 patients with thoracic Scheuermann kyphosis. The authors assessed physical examination, trunk strength measurements, serial radiographs, a detailed questionnaire, and pulmonary function studies. This study is the only one that attempts to assess pain objectively. The mean kyphosis was 71°, and average follow-up was 32 years. Study subjects worked in lighter jobs than did the controls, had more severe back pain, and were more concerned about their appearance but did not appear to be disabled by their symptoms. They found that 38% of the patients with Scheuermann kyphosis had significant interference with activities of daily living because of pain compared with 21% of controls. This study did not address the issue of kyphosis progression, which is possibly the most common concern among adolescents seeking medical attention. Using levels of evidence assessment this would be considered a Level III study.15,16 No other manuscripts were found dealing with the natural history of untreated Scheuermann kyphosis.

Neurologic complications secondary to severe kyphosis, dural cysts, or thoracic disc herniation have all been described in a small number of patients with untreated Scheuermann kyphosis.17–19 These case series and case reports are Level V evidence.

Because of the lack of literature regarding the natural history of Scheuermann kyphosis, there are questions that still need to be answered in order to improve the recommendations for treatment. Studies evaluating the natural history of Scheuermann kyphosis with different curve magnitudes, particularly those between 70° and 90°, are critically needed to guide clinicians with regard to both surgical and brace treatment.

Nonoperative Treatment

The literature search uncovered 4 articles dealing with the nonoperative treatment of Scheuermann kyphosis: 1 dealt with long-term therapeutic exercise and the other 3 with brace treatment. Although pain leads some (particularly adult) patients to seek medical treatment, Murray et al8 noted that pain is not an inevitable consequence of kyphotic deformity. There appears to be a subset of patients with refractory pain that warrants aggressive treatment. Weiss et al20 reported their results of long-term physical therapy, osteopathy, manual therapy, exercise program, and psychologic therapy for a group of 351 patients (17–21 years of age) with painful Scheuermann kyphosis. Patients reported their pain level before and after treatment using a standard visual analogue scale (VAS), a numbered scale, and a pain frequency scale. The magnitude of the kyphoses was not reported. Pretreatment pain severity averaged 2.9 in females and 2.0 in males. At the end of treatment, both the VAS and the numbered scale showed a pain reduction between 16% and 32%, which was significant in all cases. This study represents Level IV evidence.

Each of the 3 papers dealing with the efficacy of brace treatment was retrospective, had differing inclusion criteria, and did not have control groups. All had reasonable follow-up. Perhaps due to incomplete understanding of the natural history, the indications for brace treatment are not well defined and differ between these papers. Bracing has been widely regarded as efficacious in the treatment of kyphosis secondary to Scheuermann kyphosis in skeletally immature patients. Montgomery and Erwin21 reviewed 39 patients with kyphosis secondary to Scheuermann kyphosis treated with a modified Milwaukee Brace for an average of 18 months. The kyphosis before treatment averaged 62° and at the completion of brace treatment averaged 41°. Follow-up of more than 18 months after completion of brace wear showed an average of 15° loss of correction, resulting in an average overall correction of 6°. Wedging of the vertebral bodies improved from 7.9° to 6.8° with brace treatment. They found that brace treatment was successful in improving kyphosis greater than 75° in several cases.

A paper by Sachs et al14 reported on the long-term results of brace treatment of 120 patients with Scheuermann kyphosis. Patients were treated with a Milwaukee Brace at the Twin Cities Scoliosis Center. All patients were observed for at least 5 years after the completion of treatment. The average age at the initial evaluation for treatment was 12 years and 5 months, the average age at the completion of treatment was 16 years and 1 month, and the last follow-up examination was at 24 years of age. Of the patients who wore the brace consistently, 76 showed improvement in the kyphosis between the initial and follow-up evaluations; 24 patients demonstrated some worsening, and 10 were unchanged. Seven of the 24 who presented with brace treatment were subsequently treated surgically. Prebrace treatment kyphosis ranged from 45° to >75°. Patients in this study showed...
an initial improvement of 50% followed by a gradual loss of correction. When severity of prebrace kyphosis was accounted for, patients with kyphosis 55° to 64° improved an average of 7° at final follow-up, patients with kyphosis between 65° and 74° improved an average of 13°, and patients with kyphosis >74° improved an average of 19°. The authors noted that 30% of compliant patients failed brace treatment and they defined success as >3° of improvement. Four of the 14 with kyphosis >75° subsequently required a spinal fusion.

The third brace study by Riddle et al22 used the DuPont kyphosis brace in a group of 22 children with kyphosis secondary to Scheuermann kyphosis. Of these 22 children, 9 demonstrated an improvement, 7 remained unchanged, and 6 demonstrated progression of the kyphosis. It was recommended that the brace be worn until skeletal maturity, which in this series was at least 16 months. Flexible deformities seemed to predict successful brace treatment. The authors felt that the DuPont brace results were comparable to those with the Milwaukee brace and asserted additional advantage of concealment under clothes.

All of these brace studies were retrospective case series, or Level IV evidence. The data at the present time do not allow the treating physician to forecast whether brace treatment will result in improvement of the deformity, prevention of progression, or failure in any particular patient. Unfortunately, these studies do not indicate whether brace treatment actually corrects the deformity caused by Scheuermann kyphosis. Well-designed trials regarding the natural history of modest curves (70°–90°) and the ability of orthoses to correct kyphosis would be valuable.

**Surgical Treatment**

The literature search uncovered 5 papers concerning spinal surgery with multisegmental instrumentation that met the inclusion criteria. Papageopoulos et al23 described the use of posterior only hook/screw hybrid instrumentation with an average correction from 68° to 40° (42%) and an average correction loss of 6° (20%), at a mean of 4.5 years of follow-up; however, the correction loss had no apparent clinical significance. This was a retrospective case series or Level IV evidence. The loss of correction was higher in a paper by Sturm et al24 where 3 of 30 patients treated with posterior only hook constructs had broken rods resulting in revision surgery and 1 patient with both loss of correction and chronic pain. This retrospective series also represents Level IV evidence. These 2 studies suggest that posterior instrumentation with hooks and screws alone does not provide adequate strength to maintain correction.

Lowe and Kasten6 reported a retrospective series of 32 patients with Scheuermann kyphosis treated by a combined anterior release followed by posterior segmental hybrid instrumentation. The average preoperative kyphosis was 85° (75°–105°) with an average correction at final follow-up of 43° (30°–65°) and an average loss of correction at final follow-up of 4°. Proximal junctional kyphosis occurred in 5 patients and was associated with overcorrection (>50%) of the kyphosis or instrumentation short of the upper Cobb level. Distal junctional kyphosis occurred in 2 patients whose fusion ended short of the first lordotic segment. Twenty-eight patients completed an anonymous questionnaire to assess preoperative and postoperative pain and satisfaction. Twenty-seven of 28 reported preoperative thoracic back pain that interfered with activities of daily living while after surgery, and 18 of 28 complained of mild back discomfort with rigorous activity. There were no major postoperative complications in this series. This series was also retrospective, or Level IV evidence.

Lim et al25 presented a retrospective review of 23 consecutive patients with Scheuermann kyphosis who underwent operative treatment with multisegmental posterior hybrid instrumentation with or without an anterior release, which was dependent on flexibility of the kyphosis. Preoperative kyphosis ranged from 63° to 104° with a mean of 83°. Twenty (87%) of the 23 patients underwent combined procedures. Postoperative kyphosis ranged from 32° to 67° with a mean of 46°. At final follow-up, kyphosis ranged from 37° to 75° with a mean of 51°. Proximal junctional kyphosis >10° occurred in 3 patients, and no distal junctional kyphosis was noted in any patient. Minor complications included 6 patients with pleural effusions, 2 pneumothoraces, and 1 superficial wound infection. Major complications included 3 reoperations for loss of fixation of instrumentation. There were no neurologic complications. This series represents Level IV evidence.

The fifth series by Lee et al26 compared posterior only thoracic segmental pedicle screw constructs with combined anterior/posterior reconstruction using a combination of screws distally and hooks proximally with the anterior stage performed by either an open thoracotomy or thorascopic approach. Eighteen patients with Scheuermann kyphosis underwent a posterior only thoracic pedicle screw instrumented fusion while 21 underwent a combined procedure and were followed for a minimum of 2 years. This series was also Scheuermann kyphosis with a Cobb angle of ≥70°. Preoperative kyphosis averaged 89° (70°–104°) for the anterior/posterior group and 84° (70°–115°) for the posterior only group. Postoperative kyphosis averaged 52° (33°–71°) in the anterior-posterior fusion group with a 3° loss of correction at final follow-up. In the posterior only group postoperative kyphosis averaged 38° (30°–49°) with a 2° loss of correction at final follow-up. Complications in the anterior/posterior fusion group included proximal junctional kyphosis in 2 patients and distal junctional kyphosis in 1 patient. One patient developed a permanent paraplegia. Three patients developed wound infections. There were no complications in the posterior only fusion group. Postoperative SRS-30 questionnaire scores were collected on half of the combined anterior/posterior fusion patients and
all of the posterior only patients; no statistically significant differences were seen. This series suggests that posterior segmental instrumentation alone with pedicle screws provides improved fixation and holding power, when compared with combined anterior/posterior fusion using a hybrid construct, without an increased risk of postoperative complications. This series represents Level III evidence.

Both the efficacy and the potential complications of a combined anterior/posterior fusion for Scheuermann kyphosis are well documented in the literature. Hemotherax, pneumothorax, pleural effusion, postoperative wound infections, and permanent paraplegia were noted in the last 2 papers. Pulmonary function is also known to be negatively impacted by anterior surgery even at the 2-year follow-up.27

The literature on the surgical management of Scheuermann kyphosis consists primarily of retrospective case series with different inclusion criteria for surgery and without control groups. The indications for surgery remain unclear since the natural history in Scheuermann kyphosis remains controversial with regard to pain, disability, self-esteem, and deformity progression. A decision for surgery needs to be an individual one between surgeon and patient based on several components, including the patient’s symptoms and self-perception.

**Conclusion**

A review of the literature on Scheuermann kyphosis reveals many shortcomings and gaps in scientific knowledge and evidence. The etiology remains unclear, although there appears to be a strong genetic component. The natural history of Scheuermann kyphosis remains controversial, with conflicting reports on the severity of pain and physical disability. It is not known with certainty which curves are likely to progress and which will remain stable. In particular, curves with magnitudes between 70° and 90° need to be studied in more detail. Brace treatment appears to provide modest correction of the kyphosis in some cases, but the indications for brace treatment can be debated and the evidence for bracing efficacy is not conclusive.

Surgery appears to be the only way to significantly improve the kyphotic deformity associated with Scheuermann kyphosis. Deformity is the primary concern of the patient, and the benefit of correcting it should not be underestimated. The risks of surgical correction, however, are clearly defined in the literature and must be explained to the patient and parents before surgery. Early results with posterior only thoracic pedicle screws appear promising. However, prospective studies with longer follow-up using validated outcomes instruments assessing both surgical and nonsurgical patients need to be obtained.

Treatment of Scheuermann kyphosis revolves around surgery, patient, and parent opinion. Unfortunately, the current literature lacks strong levels of evidence, particularly concerning natural history and curve progression. Published surgical and nonsurgical treatment series are predominantly Level IV evidence, compromising the ability of clinicians to make strong evidence-based treatment recommendations.

**Key Points**

- Scheuermann kyphosis is the most common cause of hyperkyphosis in adolescence.
- There appears to be a major genetic contribution to etiology.
- The natural history of Scheuermann kyphosis is not well documented.
- Radiographic criteria for Scheuermann kyphosis include wedging of 3 contiguous vertebrae.
- Radiographic improvement of kyphosis is seen following both nonoperative and operative treatment of Scheuermann kyphosis based on Levels III, IV, and V evidence; however, clinical outcomes are not yet available.

**References**

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