Sagittal Alignment of the Thoracic and Lumbar Spine

Dr. Paul Missiuna
&
Dr. Carlos Lopez
Grand Rounds
May 2\textsuperscript{nd}, 2007
Terminology

► Kyphosis
  ► derived from the Greek word *kyphos*, meaning humpbacked
  ► refers to posterior rounding in the sagittal plane

► Lordosis
  ► Refers to the anterior curve in the sagittal plane
Normal maturation of sagittal alignment is established by 6 years of age

Normal Averages:

- Cervical Lordosis (C2-C7) (15°)
- Thoracic Kyphosis (T5-T12) (20°-40°)
- Lumbar Lordosis (L1-L5) (20°-55°)
Normal
Scheuermann kyphosis
Hip flexion contracture
Neuromuscular disorders
Muscular dystrophy
Kyphosis

- Multiple Etiologies:
  - Common
    - Postural
    - Scheuermann
  - Uncommon
    - Congenital
    - Neuromuscular
    - Infectious
    - Iatrogenic
    - Neoplastic
Kyphosis

Patterns of Deformity

- Non-Fixed (Most common)
  - Rounded flexible deformity
  - Associated with Postural and Scheuermann kyphosis
  - Rarely associated with neurologic compromise
  - Progression and pain (>80°) thoracic or (>50°) thoracolumbar

- Fixed (Uncommon)
  - Angular rigid deformity
  - Associated with congenital kyphosis, Neurofibromatosis, post-laminectomy kyphosis, and spine infections
  - High incidence of neurologic compromise
Postural Kyphosis

- Increased thoracic kyphosis
- Some increased lumbar lordosis
- Hip hyper-extension

Pelvic posterior tilt

Sway Back Posture
Postural Kyphosis

► History
  - Readily able to correct their deformity
  - Asymptomatic
  - Unconcerned about appearance
  - Usually tall within peer group

► Physical Exam
  - Forward shoulder posturing
  - Increased flexible thoracic kyphosis and lumbar lordosis
  - No focal tenderness or deformity
  - Pectoralis and hamstring muscle contractures
Postural Kyphosis

- 3 foot Standing X-Rays
  - AP
    - Inter-observer error is 5°
    - Normal
  - Lateral
    - Inter-observer error is 11°
    - May have dorsal kyphosis
    - NO VB wedging
    - NO end plate irregularities
    - NO disk space narrowing
    - NO Schmorl's nodes
Postural Kyphosis

► Treatment
  ▪ Maintain Normal Posture
  ▪ Exercise program
    ► Stretch pectoralis and hamstring muscle
    ► Strengthen abdominal muscles

► Prognosis
  ► No evidence that persistent postural kyphosis will result in a fixed spinal deformity or increased back pain
Scheuermann Kyphosis

► A condition characterized by
  ▪ Posterior rounding of thoracic spine associated with structural deformity of the vertebral elements

► Etiology
  ▪ Multiple theories but none established
  ▪ Theories include:
    ▪ Vertebral ring osteonecrosis, weakness of the cartilaginous endplate, osteochondrositis, transient osteoporosis, malabsorption, infection and endocrine disorders
Scheuermann Kyphosis

► Clinical Presentation
  ► More common in males
  ► Develops between 10-14yo
  ► Main reason for presentation is deformity and NOT Pain
  ► Parental concerns include
    ▪ Cosmetic deformity, progressive spinal deformity, possible development of future back pain in asymptomatic patient
Scheuermann Kyphosis

**Natural History**

- Progression of Deformity (80% of Untreated)
- Development of Pain is more frequent in thoracolumbar kyphosis along with progression but caused no significant functional problems
- Moderate Deformity (<75°) in patients had no long-term disability or significant pain problems

**Comparing S.K with control group**

- No correlations found for limitations on ADL’s, lower extremity paraesthesia, use of back pain meds, fatigue, occupation, sick leave and psychological disorders
Scheuermann Kyphosis

Physical Examination

- Unable to voluntarily correct deformity or even passively with the patient prone
- Abrupt posterior angulation of a segment
  - Mid-thoracic (More common)
  - Low thoracic or thoracolumbar (Less common)
    - Hypo-kyphosis of upper thoracic spine
- Contracture of pectoral and hamstring muscles
- Weakness of abdominal and paraspinal muscles
- Neurologic exam is normal
Scheuermann Kyphosis
Scheuermann Kyphosis

**Diagnostic Imaging**
- **AP Standing**
  - Thoracic or thoracolumbar scoliosis curve that is not progressive and rarely >25° Cobb angle
  - Inspect Risser Index
- **Lateral Standing**
  - Thoracic Kyphosis >40°, with
  - Anterior wedging of 3 or more vertebral bodies
  - Endplate irregularities, disc space narrowing, concomitant cervical and lumbar lordosis
- **Stress Lateral**
  - Demonstrates flexibility
- **MRI and CT**
  - Preoperative planning for atypical, rapid progression, congenital kyphosis or neurofibromatosis
Scheuermann Kyphosis
Scheuermann Kyphosis

Treatment and Indications

- Bracing
  - Flexible kyphosis (<40°) on stress radiograph
  - Includes stretching and muscle strengthening routine
  - Milwaukee (most common) used when apex above T8

- Casting
  - Immature patient with rigid kyphosis (>40°) on stress lateral may be serially casted to reduce to <40° where they can be treated with a brace

- Orthotics
  - Skeletally immature patient with progressive kyphosis, unacceptable cosmesis or flexible kyphosis >60°
  - Can prevent progression and cause correction
  - TLSO (most common) apex below T9

- Surgical
  - Rigid kyphosis (>50°)
Scheuermann Kyphosis
From 1960 through 1978, we analyzed the long-term results in 120 patients who had used the Milwaukee brace and had been followed for at least five years after the completion of treatment.

- 63% showed improvement in the kyphosis between the initial evaluation and the evaluation at final follow-up.
- 20% showed worsening and 8% were unchanged.

This study showed that the Milwaukee brace is usually an effective method of treatment for patients who have Scheuermann kyphosis.
75 patients with adolescent kyphosis

For compliant patients, the average improvement in kyphosis was 27% in the Boston orthosis group and 35% in the Milwaukee orthosis group.

Compliance with orthosis wearing and, therefore, effective treatment was twice as likely with the Boston orthosis (61% compliance vs. 29% with the Milwaukee).

In a small group of compliant patients with kyphotic deformities > 75°, the Milwaukee orthosis was surprisingly effective.

The Boston lumbar kyphosis orthosis offers a satisfactory alternative in patients whose curves measure less than 70°.
Large Radius Kyphosis
Large Radius Kyphosis

► Surgical Indications

- Thoracic Kyphosis >80°
- Thoracolumbar Kyphosis >50°
- Progression of deformity despite bracing
- Back pain limiting ADL’s
- Cosmetic deformity
- Pulmonary or neurologic complications
  - Unusual until >100°
Large Radius Kyphosis

- **Surgical options**
  - Posterior instrumentation and fusion
    - Skeletally immature patients with a flexible deformity
    - Skeletally mature patients who correct on stress radiographs to <50°
  - Posterior instrumentation and fusion combined with anterior fusion
    - Adolescents >50° on stress lateral
  - Anterior instrumentation and fusion
    - Pediatric pt’s with flexible deformity
  - Anterior can be done by open thoractomy or by video-assisted thorascopic surgery (VATS)
VATS
Experience With Combined Video-Assisted Thoracoscopic Surgery (VATS) Anterior Spinal Release and Posterior Spinal Fusion in Scheuermann’s Kyphosis

Spine 2005;30:2176–2181
Herrera-Soto et al.

Retrospective Review

Between 1995 and 2001,

19 pts underwent VATS and posterior spinal fusion for the treatment of Scheuermann’s kyphosis.

Average follow-up was 2.7 years.
An average of 8.3 discs were released anteriorly; an average of 13 levels were fused posteriorly.

Average preoperative kyphosis was 84.8°.
Average postoperative kyphosis was 43.7°.
Average kyphosis at follow-up was 45.3°.

Conclusions. Combined VATS release and posterior spinal fusion for the treatment of Scheuermann’s kyphosis is a viable option for the treatment of the more severe and rigid curves.
Scheuermann Kyphosis: Safe and Effective Surgical Treatment Using Multisegmental Instrumentation
Spine 2004;29:1789–1794
Moe Lim, MD et al.

Retrospective review was conducted on 23 consecutive patients who underwent surgical correction of Scheuermann kyphosis using modern multisegmental instrumentation.

Hospital charts, office charts, and radiographs were reviewed to identify complications of surgery. Complications were classified as minor, major, or life threatening.

The mean follow-up was 38 months (range 10–123 months).
Preoperative kyphosis ranged from 63° to 104° with an average of 83°.
Twenty of the 23 patients (87%) underwent combined anterior release/arthrodesis with posterior arthrodesis/multisegmental instrumentation.
The remaining 3 patients underwent posterior arthrodesis/multisegmental instrumentation.

Overall, we had 43% minor complications, 17% major complications, and 0% lifethreatening complications.

Conclusions. Surgical correction of Scheuermann kyphosis can be performed safely and effectively using modern multisegmental instrumentation.
Comparison of Scheuermann Kyphosis Correction by Posterior-Only Thoracic Pedicle Screw Fixation Versus Combined Anterior/ Posterior Fusion

Spine 2006;31:2316–2321
Lee, Stanley S. MD et al.

Retrospective comparison review.

There were 18 patients with Scheuermann kyphosis who underwent a posterior-only thoracic pedicle screw (P/TPS) fusion and 21 who underwent an anterior/posterior fusion who were followed for a 2-year minimum.

The 2 groups were well matched according to average age, maximum preoperative kyphosis, flexibility index, and posterior fusion levels.

Operating time and blood loss were noted, and radiographs were evaluated before surgery, after surgery, and at final follow-up. At final follow-up, Scoliosis Research Society-30 questionnaire data and complications were recorded.

Results. At surgery, operating time and blood loss were significantly less in the P/TPS group (P = 0.009 and P = 0.05, respectively). The mean residual kyphosis of the P/TPS group averaged 38.2° after surgery and 40.4° at final follow-up versus anterior/posterior fusion group (51.9° and 58.0°, P < 0.001 and P = 0.001, respectively). Even without an anterior release, kyphosis correction in the P/TPS group averaged 54.2% after surgery and 51.8% at final follow-up versus the anterior/posterior fusion group (41.2% and 38.5%, P = 0.001 and P < 0.001, respectively). Scoliosis Research Society-30 outcome scores at final follow-up were comparable between the 2 groups (P/TPS = 120 and anterior/posterior fusion = 128; P = 0.14). The anterior/posterior fusion group had 8/21 (38%) patients with complications, including paraplegia in 1, proximal junctional kyphosis in 1, proximal hook pullout in 1, and infection in 2. The P/TPS group had no complications (P = 0.003).

Conclusions. With less operating time and intraoperative blood loss, posterior-only Scheuermann kyphosis treatment with thoracic pedicle screws achieved and maintained better correction, and had significantly less complications than with circumferential fusion.
Short Radius Kyphosis
Short Radius Kyphosis

► Surgical Indications

▪ Congenital Spine deformity
  ▶ Type I – Anterior failure of VB formation
  ▶ Type II – Anterior failure of VB Segmentation
  ▶ Type III – Combination of formation and segmentation failure

▪ Cord compression and paraplegia are serious considerations

▪ Prior to surgical treatment cardiac, respiratory, GU and neurologic anomalies must be assessed
Short Radius Kyphosis

Surgical Options

- Posterior in situ fusion with or without instrumentation
- Combined ant. and post fusion with instrumentation
- Combined Ant-Post In-situ fusion with strut grafting or spine shortening
- Anterior can be done by open thoractomy or by video-assisted thorascopic surgery (VATS)
A retrospective study

Sixty-five patients with a congenital kyphosis (n = 14) or kyphoscoliosis (n = 51) were treated by five different methods of spine arthrodesis: prophylactic posterior arthrodesis before age of 5 years (n = 11), posterior arthrodesis after age 5 years without instrumentation (n = 26) and with instrumentation (n = 12), combined anterior and posterior arthrodesis without instrumentation (n = 7) and with instrumentation (n = 9). All 65 patients were observed for a minimum of 2 years (mean 6 years 6 months, range 2 to 18 years). Fifty-seven patients reached skeletal maturity.

Conclusion. All patients with a Type I or Type III congenital kyphosis or kyphoscoliosis should be treated by a posterior arthrodesis before the age of 5 years and before the kyphosis exceeds 50°. A kyphosis that does not reduce to less than 50° as measured on the lateral spine radiograph made with the patient supine requires an anterior release and arthrodesis with strut grafting followed by posterior arthrodesis with instrumentation (if possible).
Summary

► Treatment of Large radius kyphosis is primarily non-surgical
  ▪ Surgery should be reserved for >80° curves and painful and progressive deformities

► Congenital kyphosis requires:
  ▪ Early diagnosis and treatment with posterior fusion to prevent progression of deformity

► Short radius fixed deformities require combined fusion with VATS as an option

► Patients with neurologic symptoms require formal anterior decompression and posterior fusion