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Evaluation of Spinal Alignment: Part I—Coronal Alignment

Charles Kuntz IV, MD

Learning Objectives: *After participating in this CME activity, the neurosurgeon should be better able to:*
1. *Describe clinical and radiographic measurements in analysis of spinal alignment.*
2. *Use a systematic approach to analyze regional and global coronal spinal alignment from the occiput to the pelvis.*

This article is the first of 2 parts.

Neutral upright spinal alignment (NUSA) in asymptomatic individuals is defined as standing with the knees and hips comfortably extended, the shoulders neutral or flexed, the neck neutral, and gaze horizontal. The ability to maintain NUSA is intrinsic to the human condition. Many spinal procedures are performed to return the patient to asymptomatic NUSA. Part I of this 2-part series discusses coronal alignment in detail.

Despite wide variations in "normal" regional spinal alignment in asymptomatic individuals, global NUSA from the occiput to the pelvis is maintained in a relatively narrow range for maintenance of horizontal gaze and balance of the spine over the pelvis and femoral heads (Figures 1 and 2, Table 1). As alignment changes in one region of the spine in asymptomatic individuals, compensatory changes occur in adjacent regional axial skeletal alignment to maintain global spinal alignment. In the coronal plane, the pelvis is relatively fixed so that as a regional spinal scoliosis develops, compensatory scoliotic curves develop (rotating in the opposite direction) above and below the main scoliosis to maintain neutral coronal global spinal alignment.

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The human spine is a complex organ that has 4 major functions: (1) to support the head, upper extremities, and torso; (2) to protect the spinal cord and nerve roots; (3) to control complex axial skeletal movements; and (4) to transmit the body's weight to the hips by articulation with the pelvis. In reviewing the literature and in the author's experience, it is important to recognize the 4 critical components for treating spinal alignment problems: (1) to achieve satisfactory neural element decompression; (2) to maintain or restore global spinal alignment to neutral; (3) to maintain or restore pelvic alignment to neutral; and (4) to maintain or restore regional spinal alignment to neutral.

The spine is composed of regions with distinct alignment and biomechanical properties that contribute to global alignment. Spinal deformity is defined as a deviation from normal spinal alignment. Because the human condition is in part defined by the ability to stand comfortably upright, and because the treatment of many patients with spinal disorders is directed at restoring this condition, spinal deformity needs to be defined in relation to NUSA in asymptomatic individuals. Analysis of spinal alignment involves both clinical and radiographic evaluation. Although there is a myriad of angles and displacements for measuring spinal alignment, the author's analysis, given herein, offers a systematic approach to analyzing regional and global spinal alignment from the occiput to the pelvis.

Category: Spine

Key Words: Spine, Coronal, Alignment, Deformity

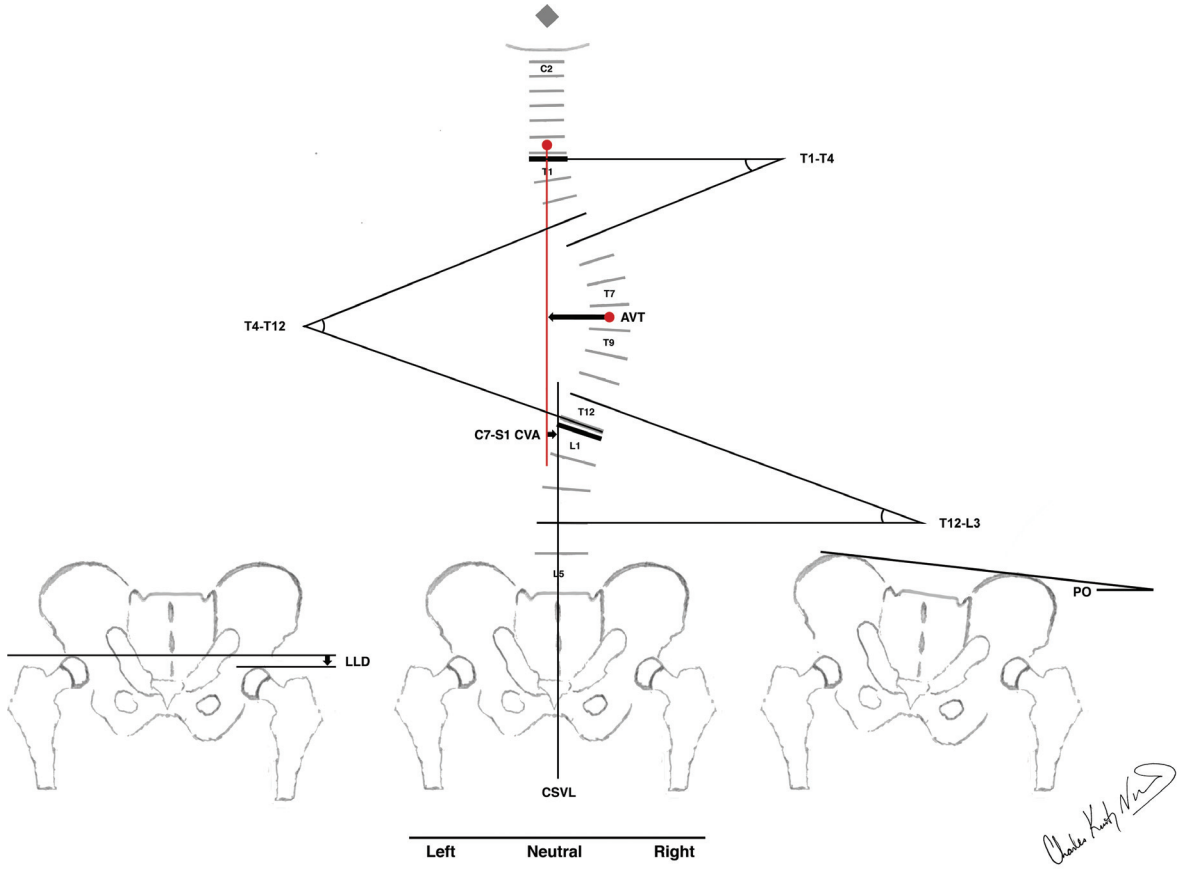

Figure 1. Schematic illustration of anteroposterior radiographic images of the spine from the occiput to the pelvis shows regional and global neutral upright coronal spinal alignment. Radiographic coronal spinal angles and displacements from the occiput to the pelvis are depicted. (Used with permission from the Mayfield Clinic.)

Clinical and Radiographic Evaluation of Spinal Alignment

For the purpose of evaluating a spinal deformity, the following steps are taken:

1. Clinical measurements are obtained (facilitated with photographs) with the patient in a neutral upright position (standing with the knees and hips comfortably extended, the shoulders and neck neutral) and in a forward-bend position (standing with feet together, the knees comfortably extended, the hips and spine flexed, and the arms dependent with fingers and palms opposed).
2. Occipitocervical and cervical angles and displacements are measured on standard standing anteroposterior and lateral cervical spine radiographs with the patient in a

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Table 1. CKIV Neutral Upright Coronal Spinal Alignment Guide: Asymptomatic Adult Individuals*

	Neutral Values, Mean (1 SD)†
Regional spinal alignment	
Occipitocervical junction angle (degrees)	
O–C2 apex	—
Cervical angle (degrees)	
C2–C3 disc to C6–C7 disc apex	—
Cervicothoracic junction angles (degrees)	
C7–T1 apex	—
Proximal thoracic angle (degrees)	
T1–T2 disc to T5 apex	<20‡
Main thoracic angle (degrees)	
T5–T6 disc to T11–T12 disc apex	<20‡
Thoracolumbar angle (degrees)	
T12–L1 apex	<20‡
Lumbar angle (degrees)	
L1–L2 disc to L4–L5 disc apex	<20‡
Lumbosacral junction angle (degrees)	
L5–S1 apex	—
ShTA (degrees)	1 (2)
ATI (degrees)	—
AVT (mm)	—
AVR (degrees)	<5–10‡
Pelvic alignment	
Pelvic obliquity (degrees)	<8‡
Leg length discrepancy (mm)	6 (4)
Global spinal alignment	
Head tilt angle (degrees)	
IPA	0 (1)
Coronal spinal balance (mm)	
TT–S1 CVA	—
C7–S1 CVA	+4 (12)

*Pooled estimates of the mean and variance of the neutral upright coronal spinal angles and displacements from the occiput to the pelvis in asymptomatic individuals. Assuming a normal distribution for coronal spinal angles and displacements in the population, the mean ± 1 SD includes approximately 68% population, the mean ± 2 SD includes approximately 95% population, and the mean ± 2.5 SD includes approximately 98.5% of the population. (For empty data cells, there was little or no reproducible data.)

†Adult older than 18 years.

‡Approximately 98.5% of asymptomatic individuals have coronal curves less than the estimated angle.

AVR, apical vertegral rotation; ATI, angle of trunk inclination; AVT, apical vertebral translation; CVA, coronal verebral axis; IPA, interpupillary angle; SD, standard deviation; ShTA, shoulder tilt angle. (Used with permission from the Mayfield Clinic.)

neutral upright position (standing with the knees and hips comfortably extended, the shoulders and neck neutral).

3. Thoracic, lumbar, sacral, and pelvic angles and displacements, including spinal balance, are measured on standard standing anteroposterior and lateral long cassette radiographs with the patient in a neutral upright standing position [standing with the knees and hips comfortably extended, the shoulders neutral or flexed (flexed for lateral radiographs), and the neck neutral].
4. Side-bending (supine) and flexion/extension (standing) radiographs are obtained when appropriate for evaluating the flexibility of a deformity curve.

All upright imaging is performed with the patient barefoot. In patients with increased/decreased thoracic/lumbar vertebrae, the anomalous vertebrae are included in the appropriate alignment-biomechanical zone. Leg length discrepancy (LLD) less than 2 cm is ignored unless the LLD significantly contributes to the spinal deformity. When LLD is greater than 2 cm, an appropriately thick lift is placed under the shorter leg.

Coronal Alignment Angles and Displacements

By convention, coronal angles have a (+) value. Scoliotic curves are named for the convexity to the right or left. Coronal angulation of the head, shoulders, or pelvis is named for the elevated side: right is right up, and left is left up.

Regional Spinal Alignment

Shoulder tilt angle (ShTA) is defined as the angle subtended by a horizontal reference line and a line drawn through the right and left coracoid processes. Trunk asymmetry (distortions of the torso) is measured using a scoliometer with the patient in a forward bend position (standing with feet together, the knees comfortably extended, the hips and spine flexed, and the arms dependent with fingers and palms opposed). The angle of trunk inclination (ATI) is the angle between a horizontal reference line and the plane across the back at the greatest elevation of a rib prominence or lumbar prominence. In contrast to radiographic measurements, the ShTA and ATI are clinical measurements of the effect of regional spinal deformity on trunk symmetry.

Occipitocervical (O–C2) curves are defined as having an apex from the occiput to C2; a coronal occipital reference line and the caudal end vertebrae are defined for measuring the Cobb angle.

Cervical coronal curves are defined as having an apex from the C2–C3 disc to C6–C7 disc and measured by the Cobb method from the end vertebrae.

The cervicothoracic junction angles are defined from C7 to T1. Cervicothoracic coronal curves are defined as having an apex from C7 to T1 and measured by the Cobb method from the end vertebrae.

Proximal thoracic (T1–T2 disc to T5), main thoracic (T5–T6 disc to T11–T12 disc), thoracolumbar (T12–L1), lumbar (L1–L2 disc to L4–L5 disc), and lumbosacral (L5–S1) coronal curves are defined as having an apex in the above regions or zones and measured by the Cobb method from the end vertebrae. The end vertebrae for all coronal curves are defined as the most cephalad and caudad vertebrae that maximally tilt into the concavity of the curve. The end vertebrae define the ends of the scoliotic curve. The cephalad end vertebra is the first vertebra in the cephalad direction from a curve apex whose *superior* surface is tilted maximally toward the concavity of

the curve. The caudad end vertebra is the first vertebra in the caudad direction from a curve apex whose *inferior* surface is tilted maximally toward the concavity of the curve. The apical vertebra or disc of a curve is defined as the most horizontal and laterally deviated vertebra or disc of the curve. Apical vertebral translation is defined as the horizontal distance measured from the C7 plumb line to the center of the apical vertebral body or disc for proximal thoracic and main thoracic curves and from the central sacral vertical line (CSVL) to the center of the apical vertebral body or disc for thoracolumbar and lumbar curves. The CSVL is defined as a vertical reference line drawn through the center of the S1 endplate. Apical vertebral rotation (AVR) is defined by the Nash-Moe classification system. (Because AVR is defined on anteroposterior radiographs, AVR is included with the coronal alignment.) Lateral olisthesis is defined by a modified Meyerding classification system. For lumbosacral coronal curves, the apical vertebra or disc is defined from L5 to S1; the cephalad end vertebra and a horizontal reference line are defined for measuring the Cobb angle (on supine side-bending radiographs, the horizontal reference line may be reconstructed from the standing radiographs).

Pelvic Alignment

Pelvic alignment and morphology are defined by the pelvic obliquity (PO) and LLD. PO is defined most frequently as the angle subtended by a horizontal reference line and a line drawn tangential to the top of the crests of the ilium or the base of the sulci of the S1 ala. PO may result from an intrinsic sacropelvic deformity, LLD, or a combination of the both. LLD is defined as the vertical distance measured between horizontal lines drawn tangential to the top of the right and left femoral heads.

Global Spinal Alignment

Head tilt is defined by the interpupillary angle (IPA). The IPA is defined as the angle subtended by a horizontal reference line and the interpupillary line. The interpupillary line is defined by a line drawn through the center of the right and left pupils. In contrast to radiographic measurements, the IPA is a clinical measurement of total coronal deformity of the spine and the effect on horizontal gaze.

Coronal spinal balance is defined from the center of C7 and the midpoint of the thoracic trunk to the sacrum. The C7–S1 coronal vertical axis (C7–S1 CVA) is defined as the

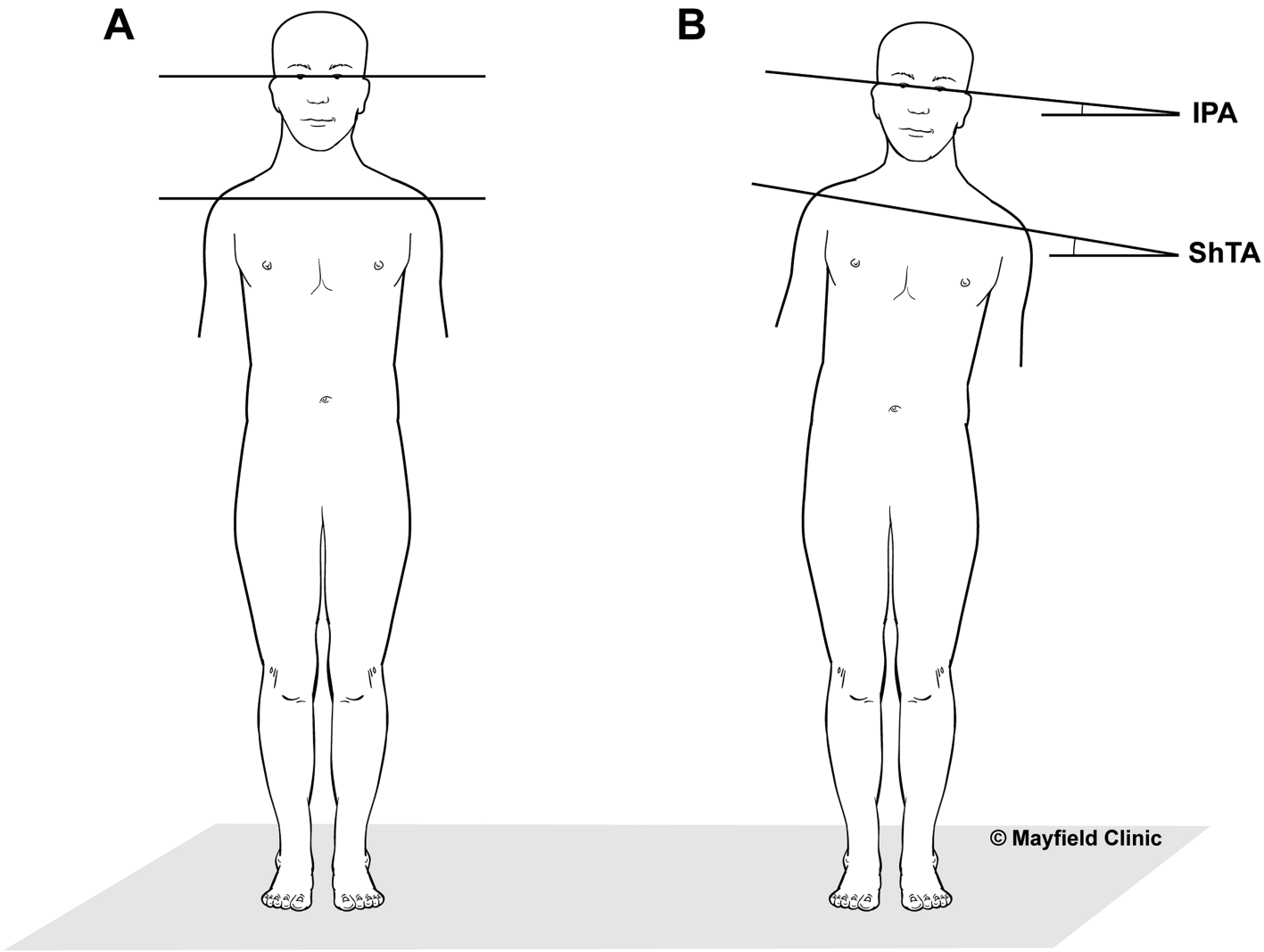

Figure 2. Schematic illustration showing clinical measurement of the IPA and ShTA. ***A***, Normal IPA and ShTA. ***B***, IPA and ShTA with a coronal plane deformity. (Used with permission from the Mayfield Clinic.)

horizontal distance measured from a vertical plumb line centered in the middle of the C7 vertebral body to the CSVL. The C7–S1 CVA has a (+) value when the vertical plumb line is right of the CSVL and a (−) value when the vertical plumb line is left of the CSVL. The thoracic trunk–S1 coronal vertical axis (TT–S1 CVA) is defined as the horizontal distance measured from a vertical plumb line centered at the midpoint of the thorax to the CSVL (also known as thoracic trunk shift). The TT–S1 CVA is measured at the midpoint between the rib cage on the left and the rib cage on the right at the level of the main thoracic apical vertebra; if there is no main thoracic apical vertebra, the TT–S1 CVA is measured at the level of T9. The TT–S1 CVA has a (+) value when the vertical plumb line is right of the CSVL and a (−) value when the vertical plumb line is left of the CSVL.

Summary

The spine must be evaluated in its entirety from the occiput to the pelvis before a treatment plan is formulated. The axial skeleton is composed of spinal regions with distinct alignment and biomechanical properties that contribute to global spinal alignment. Although regional curves vary widely from the occiput to the pelvis in asymptomatic individuals, global spinal alignment is maintained in a much narrower range for maintenance of horizontal gaze and balance of the spine over the pelvis and femoral heads. Spinal deformity is defined as a deviation from normal spinal alignment. The 4 critical components for treating spinal alignment problems include: (1) achieving satisfactory neural element decompression; (2) maintaining or restoring global spinal alignment to neutral; (3) maintaining or restoring pelvic alignment to neutral; and (4) maintaining or restoring regional spinal alignment to neutral. This article, part I of a 2-part series, has described the coronal clinical and radiographic measurements when analyzing spinal alignment and deformity. In part II, sagittal alignment will be discussed in detail.

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1. In the coronal plane, the pelvis is relatively fixed so that as a regional spinal scoliosis develops, compensatory scoliotic curves develop (rotating in the opposite direction) above and below the main scoliosis to maintain neutral coronal global spinal alignment.

   True or False?

2. As alignment changes in one region of the spine in asymptomatic individuals, compensatory changes occur in adjacent regional axial skeletal alignment to maintain global spinal alignment.

   True or False?

3. The 4 critical components for treating spinal alignment problems are as follows: (1) achieve satisfactory neural element decompression; (2) maintain or restore global spinal alignment to neutral; (3) maintain or restore pelvic alignment to neutral; and (4) maintain or restore regional spinal alignment to neutral.

   True or False?

4. Leg length discrepancy less than 4 cm is ignored unless the leg length discrepancy significantly contributes to the spinal deformity. When the leg length discrepancy is 4 cm or more, an appropriately thick lift is placed under the shorter leg.

   True or False?

5. In contrast to radiographic measurements, the ShTA and ATI are clinical measurements of the effect of regional spinal deformity on trunk symmetry.

   True or False?

6. Cervical coronal curves are defined as having an apex from the C3–C4 disc to C5–C6 disc and measured by the Cobb method from the end vertebrae.

   True or False?

7. The end vertebrae for all coronal curves are defined as the most cephalad and caudad vertebrae that maximally tilt into the concavity of the curve, and the end vertebrae define the ends of the scoliotic curve.

   True or False?

8. Pelvic obliquity may result from an intrinsic sacropelvic deformity, leg length discrepancy, or a combination of the 2.

   True or False?

9. The interpupillary line is defined by a line drawn through the center of the right and left pupils.

   True or False?

10. The C7–S1 CVA has a (−) value when the vertical plumb line is right of the CSVL and a (+) value when the vertical plumb line is left of the CSVL.

    True or False?

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Evaluation of Spinal Alignment: Part II—Sagittal Alignment

Charles Kuntz IV, MD

Learning Objectives: *After participating in this CME activity, the neurosurgeon should be better able to:*
1. *Describe clinical and radiographic measurements in the analysis of spinal alignment.*
2. *Use a systematic approach to analyze regional and global sagittal spinal alignment from the occiput to the pelvis.*

This article is the second of 2 parts.

Despite wide variations in "normal" regional spinal alignment in asymptomatic individuals, global neutral upright spinal alignment from the occiput to the pelvis in asymptomatic individuals is maintained in a relatively narrow range for maintenance of horizontal gaze and balance of the spine over the pelvis and femoral heads (Figures 1 and 2, Table 1). As alignment changes in one region of the spine in asymptomatic individuals, compensatory changes occur in adjacent regional axial skeletal alignment to maintain global spinal alignment. In the sagittal plane, the pelvis may rotate on the femoral heads so that as regional spinal kyphosis develops, the pelvis rotates posteriorly on the femoral heads and compensatory lordotic spinal changes develop above and below main kyphosis to maintain neutral sagittal global spinal alignment. In the sagittal plane, as regional spinal lordosis develops, the pelvis may rotate anteriorly on the femoral heads and compensatory kyphotic spinal changes develop above and below main lordosis to maintain neutral global spinal alignment.

This second part of a 2-part series provides an extensive review of clinical and radiographic measurements in the analysis of spinal alignment. After completing this activity, the neurosurgeon should be better able to use a systematic approach when analyzing regional and global spinal alignment from the occiput to the pelvis.

Clinical and Radiographic Evaluation of Spinal Alignment

Sagittal Alignment Angles and Displacements

By convention, kyphosis has a (+) value, and lordosis has a (−) value.

Regional Spinal Alignment

Occipitocervical junction angles are defined from the occiput to C2. The O–C2 angle is defined as the angle subtended by the McGregor line and a line drawn parallel to the inferior endplate of C2. The McGregor line is drawn from the posterosuperior aspect of the hard palate to the most caudal point on the midline of the occipital curve. The C1–C2 angle is defined as the angle subtended by a line drawn parallel to the inferior aspect of C1 and a line drawn parallel to the inferior endplate of C2.

Cervical lordosis angles are defined from C2 to C7. The C2–C7 angle is defined as the angle subtended by a line drawn parallel to the posterior border of the C2 vertebral body and a line drawn parallel to the posterior border of the C7 vertebral body.

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Category: Spine

Key Words: Spine, Sagittal, Alignment, Deformity

Cervicothoracic junction angles are defined from C6 to T2, as measured by the Cobb method. The C6–T2 angle is measured from the superior endplate of C6 to the inferior endplate of T2.

Thoracic kyphosis angles are defined from T1 to T12, as measured using the Cobb method. Total thoracic kyphosis is measured from the superior endplate of T1 to the inferior endplate of T12. The proximal thoracic kyphosis is measured from the superior endplate of T1 to the inferior endplate of T5. The main thoracic kyphosis is measured from the superior endplate of T4 to the inferior endplate of T12.

Thoracolumbar junction angles are defined from T10 to L2, as measured using the Cobb method. The T10–L2 angle is measured from the superior endplate of T10 to the inferior endplate of L2.

Lumbosacral lordosis angles are defined from T12–L1 to S1, as measured using the Cobb method. Total lumbosacral lordosis is measured from either the inferior endplate of T12 or the superior endplate of L1 to the superior endplate of S1. Lumbar lordosis is measured from the superior endplate of L1 to the inferior endplate of L5.

Lumbosacral junctional angles are measured from L4 to S1, as measured using the Cobb method. The L4–S1 angle is measured from the superior endplate of L4 to the superior endplate of S1. The L4–L5 angle is measured from the superior endplate of L4 to the superior endplate of L5. The L5–S1 angle is measured from the superior endplate of L5 to the superior endplate of S1.

Anterior and posterior olisthesis are defined by a modified Meyerding classification system.

Pelvic Alignment

Pelvic morphology and rotation are defined by the pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS). PI is a constant value unaffected by body posture. PI is defined as an angle subtended by a line drawn from the hip axis (HA) to the midpoint of the sacral endplate and a line perpendicular to the center of the sacral endplate. HA is defined as the midpoint between the approximate centers of both femoral heads. As PI increases, lumbosacral lordosis must increase to maintain balanced sagittal global spinal alignment. In contrast to PI, the SS and PT are posturally dependent values and change with rotation of the pelvis on the HA. SS is defined as the angle subtended by a horizontal reference line and the sacral endplate. PT is defined as the angle subtended by a vertical reference line through the HA and a line drawn from the midpoint of the sacral endplate to the HA. PT has a (+) value when the midpoint of the sacrum is posterior to the vertical reference line and a (−) value when the midpoint of the sacrum is anterior to the vertical reference line. Geometrically, these pelvic angles produce the following equation: PI = SS + PT. The pelvis rotates on the HA to help maintain balanced sagittal global spinal alignment.

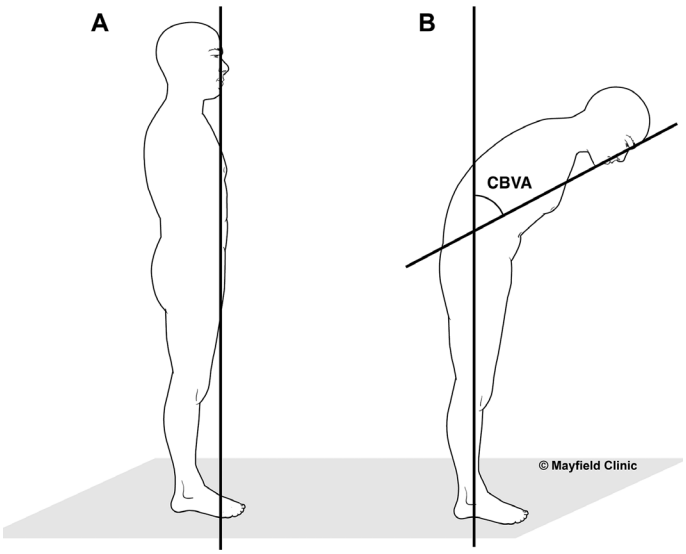

Figure 1. Schematic illustration shows clinical measurement of the CBVA. ***A,*** normal CBVA. ***B,*** CBVA with a sagittal plane deformity. CBVA, chin-brow to vertical angle. Copyright Mayfield Clinic. (Used with permission from the Mayfield Clinic.)

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Global Spinal Alignment

Chin-brow to vertical angle is defined as the angle subtended by a vertical reference line and a line drawn parallel to the chin and brow, with the neck in neutral or fixed position and the knees and hips extended. In contrast to the radiographic measurements, the chin-brow to vertical angle is a clinical measurement of the total sagittal deformity of the spine and the effect on horizontal gaze.

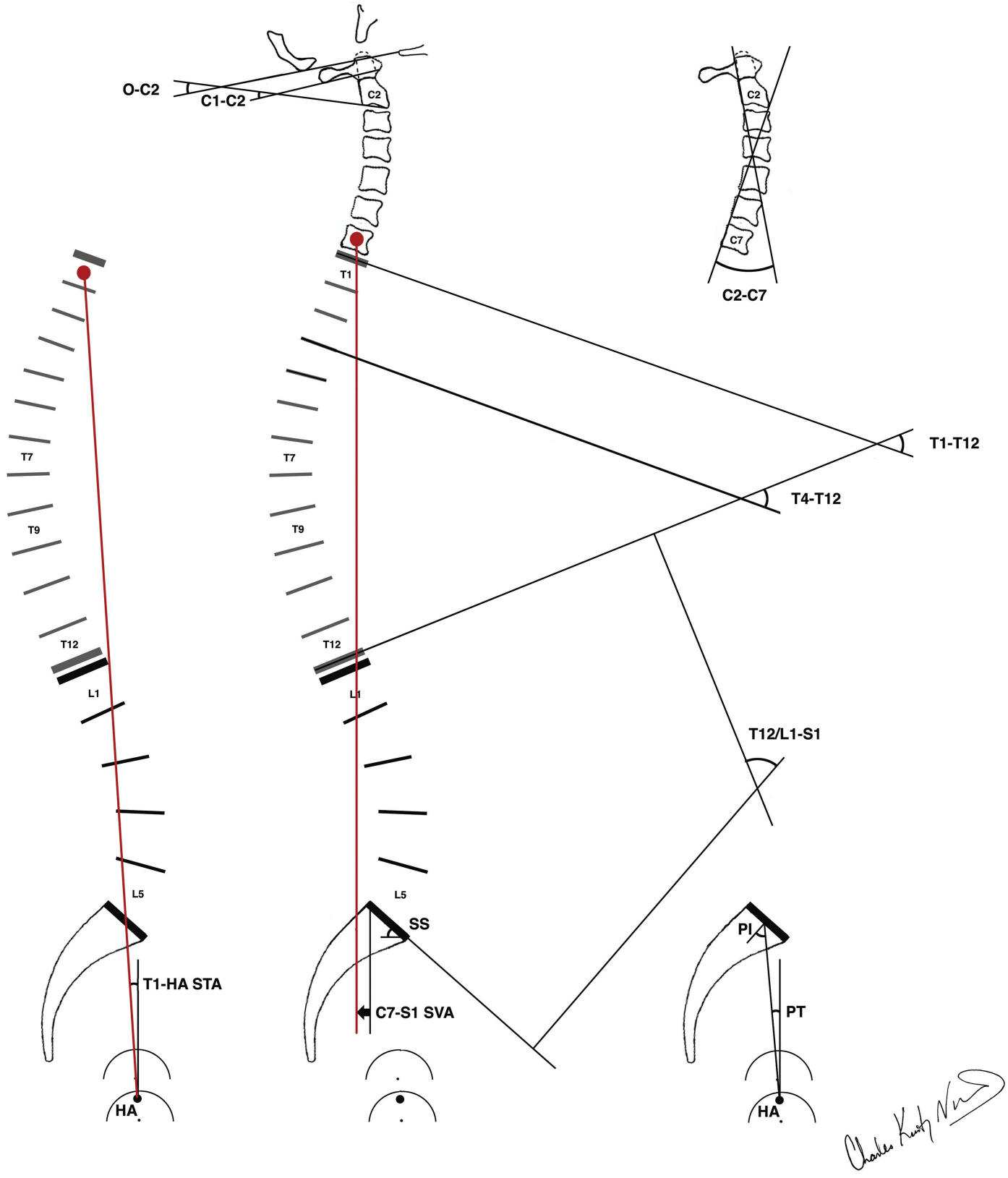

Figure 2. Schematic illustration of lateral radiographic images of the spine from the occiput to the pelvis shows regional and global neutral upright sagittal spinal alignment. Radiographic sagittal spinal angles and displacements from the occiput to the pelvis are depicted. SVA, sagittal vertical axis. (Used with permission from the Mayfield Clinic.)

Table 1. CKIV Neutral Upright Sagittal Spinal Alignment Guide: Asymptomatic Adult Individuals*

	Neutral Values, Mean (1 SD)†
Regional spinal alignment	
Occipitocervical junction angles (degrees)	
O–C2	−14 (7)
C1–C2	−29 (7)
Cervical lordosis (degrees)	
C2–C7	−17 (14)
Cervicothoracic junction angle (degrees)	
C6–T2	—
Total thoracic kyphosis (degrees)	
T1–T12	+45 (10)
Proximal thoracic kyphosis (degrees)	
T1–T5	+14 (8)
Main thoracic kyphosis (degrees)	
T4–T12	+41 (11)
Thoracolumbar junction angle (degrees)	
T10–L2	+6 (8)
Total lumbosacral lordosis (degrees)	
T12/L1–S1	−62 (11)
Lumbar lordosis (degrees)	
L1–L5	−44 (11)
Lumbosacral junction angles (degrees)	
L4–S1	—
L4–L5	−17 (5)
L5–S1	−24 (6)
Pelvic alignment (degrees)	
PI	+54 (10)
PT	+13 (6)
SS	+41 (8)
Global spinal alignment	
Chin-brow to vertical angle (degrees)	
CBVA	−1 (3)
Sagittal spinal balance	
C7–S1 SVA (mm)	0 (24)
T1-HA STA (degrees)	−1 (3)
T9-HA STA (degrees)	−11 (3)

*Pooled estimates of the mean and variance of the neutral upright sagittal spinal angles and displacements from the occiput to the pelvis in asymptomatic individuals. Assuming a normal distribution for sagittal spinal angles and displacements in the population, the mean ± 1 SD includes approximately 68% population, the mean ± 2 SD includes approximately 95% population, and mean ± 2.5 SD includes approximately 98.5% of the population. For empty data cells, there were little or no reproducible data. (Used with permission from the Mayfield Clinic.)

†Adult older than 18 years.

CBVA, chin-brow to vertical angle; HA, hip axis; PI, pelvic incidence; PT, pelvic tilt; SS, sacral slope; STA, sagittal tilt angle; SVA, sagittal vertical axis.

Sagittal spinal balance is defined from C7, T1, and T9 to the sacrum or HA. The C7–S1 sagittal vertical axis is defined as the horizontal distance measured from a vertical plumb line centered in the middle of the C7 vertebral body to the posterior superior corner of the S1 endplate. The C7–S1 sagittal vertical axis has a (+) value when the vertical plumb line is anterior to the sacral reference point and a (−) value when the vertical plumb line is posterior to the sacral reference point. The T1-HA sagittal tilt angle (T1-HA STA) is defined as the angle subtended by a vertical reference line through the HA and a line drawn from the midpoint of the T1 vertebral body to the HA. The T9-HA STA was defined as the angle subtended by a vertical reference line through the HA and a line drawn from the midpoint of the T9 vertebral body to the HA. The T1-HA STA and T9-HA STA have a (+) value when the T1 or T9 midpoint is anterior to the HA vertical reference line and a (−) value when the T1 or T9 midpoint is posterior to the HA vertical reference line.

Summary

The spine needs to be evaluated in its entirety from the occiput to the pelvis before a treatment plan is formulated. The axial skeleton is composed of spinal regions with distinct alignment and biomechanical properties that contribute to global spinal alignment. Although regional curves vary widely from the occiput to the pelvis in asymptomatic individuals, global spinal alignment is maintained in a much narrower range for maintenance of horizontal gaze and balance of the spine over the pelvis and femoral heads. Spinal deformity is defined as a deviation from normal spinal alignment. The 4 critical components to treating spinal alignment problems include: (1) achieving satisfactory neural element decompression; (2) maintaining or restoring global spinal alignment to neutral; (3) maintaining or restoring pelvic alignment to neutral; and (4) maintaining or restoring regional spinal alignment to neutral.

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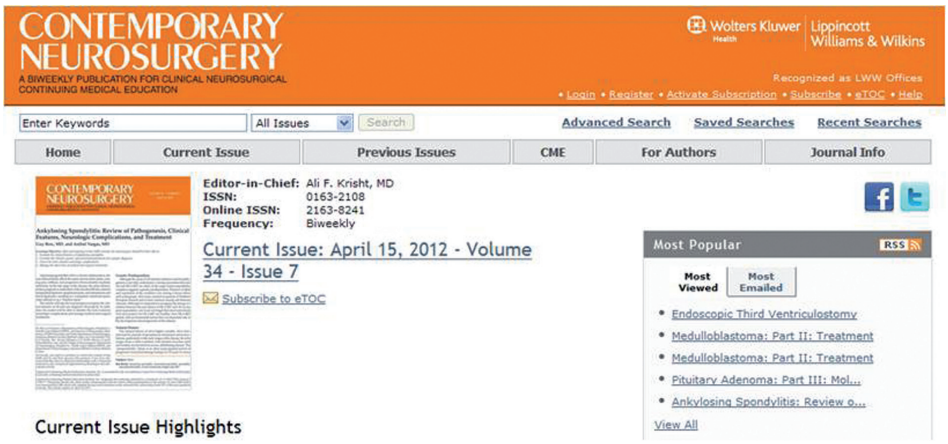

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1. In the sagittal plane, the pelvis may rotate on the femoral heads so that as regional spinal kyphosis develops, the pelvis rotates posteriorly on the femoral heads and compensatory lordotic spinal changes develop above and below main kyphosis to maintain neutral sagittal global spinal alignment.

   True or False?

2. In the sagittal plane, as regional spinal lordosis develops, the pelvis may rotate anteriorly on the femoral heads and compensatory kyphotic spinal changes develop above and below main lordosis to maintain neutral global sagittal spinal alignment.

   True or False?

3. The C1–C2 angle is defined as the angle subtended by a line drawn perpendicular to the posterosuperior aspect of C1 and a line drawn parallel to the inferior endplate of C2.

   True or False?

4. The Cobb method is used to measure angles of the cervicothoracic junction, thoracic kyphosis, and lumbosacral junction.

   True or False?

5. Pelvic morphology and rotation are defined by the pelvic incidence, pelvic tilt, and sacral slope.

   True or False?

6. Pelvic incidence is a constant value unaffected by body posture. As pelvic incidence increases, lumbosacral lordosis must increase to maintain balanced sagittal global spinal alignment.

   True or False?

7. Unlike pelvic incidence, sacral slope and pelvic tilt are posturally dependent values.

   True or False?

8. Pelvic tilt has a (+) value when the midpoint of the sacrum is posterior to the vertical reference line and a (−) value when the midpoint of the sacrum is anterior to the vertical reference line.

   True or False?

9. In contrast to radiographic measurements, CBVA is a clinical measurement of the total sagittal deformity of the spine and the effect on horizontal gaze.

   True or False?

10. The C7–S1 sagittal vertical axis has a (−) value when the vertical plumb line is anterior to the sacral reference point and a (+) value when the vertical plumb line is posterior to the sacral reference point.

    True or False?