Reading between the lines

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Studying x-rays is a passion for many of us. We spend hours poring over films alone in our offices, with patients and at seminars with our colleagues—always trying to learn more about the patient and what is possible. As students we learned to put lines on films to measure things, and as our knowledge grew we realized that the analysis is not so much about those lines as it is about what they represent and the clues hidden between them on the film. Still, those lines are important and sometimes we need to investigate new lines and new ways of looking at the spine in order to improve our understanding.

The chiropractic biophysics doctors have published more on spinal x-ray analysis than any other technique in our profession, especially within the last 20 years. While we may disagree on methods, there is much to learn by looking at their findings. In 2002 they published a paper in *European Spine Journal* entitled "*How do anterior/posterior translations of the thoracic cage affect the saddle lumbar spine, pelvic tilt and thoracic kyphosis?"* This is something that is not addressed in *The Chapters* or in Plaugher's text, and I found the results quite interesting.

In *The Chapters* we are taught that the lumbar lordosis increases as the sacral angle increases and that it decreases as the sacral angle decreases. This makes sense in a normal or properly adapting spine. As the lumbar curve increases, barring any bony deformity, the thoracic curve will tend to increase accordingly. The opposite is also true.

Often times when patients present to the office, their lack of these normal expected findings fits perfectly with their case, but sometimes they don't. Sometimes we do not see the changes we would expect to find on our post films and I believe that this paper explores some of the reasons.

The findings of note are: 26° of kyphosis occur in the anterior/posterior translation of the thoracic cage (60% of this being at T8-T 12), the thoracic kyphosis straightens in anterior translation and increases in posterior translation. The pelvis tilts forward in anterior thoracic cage translations while the lower lumbars flex and the upper lumbars extend. The pelvis extends backward in the posterior thoracic cage translations and the lower lumbars extend in the upper lumbars creating an "S" configuration. Lastly, when comparing the displacement of T12 to the femur head there was approximately 85 mm anterior translation and 73 mm posterior translation.

Let's look at each of these: 26° of kyphosis occur in the anterior/posterior translation of the thoracic cage (60% of this being at T8-T 12). Daigo Morita et al used wedges to measure maximum passive ROM of the T spine. They found, " Total ROM (T1/L1) was 31.7 ± 11.3. Segmental ROM decreased from T1/2 to T4/5 but increased gradually from T4/5 to T12/L1. Maximum ROM was at T12/L1 (4.2 ± 2.1) and minimum at T4/5 (0.9 ± 3.0)" which is consistent with the Harrison's findings.

These studies essentially agreed that the majority of the motion in the thoracic spine takes place between T8-12 (62%). The authors in both papers speculate that this is due to the floating ribs. I would suggest that it is more likely because the height of the discs in these levels has a greater impact on this finding. A thinner disc simply has less room to move and as you progress up through the thoracic spine the discs significantly thin. A similar factor is seen with a degenerated disc. As the endplates of a motion segment approximate, there is simply less room to move.

Thoracic kyphosis decreases during anterior translation and increases in posterior translation. This makes sense. As the thoracic spine moves anterior there has to be a change in the kyphosis. They tried to minimize any tilting of the thoracic spine between T12 and T1 or rotation of the thoracic spine in the sagittal plane in general in this study. They had the subjects move the thoracic spine as a unit. As it moves forward in order to stop from tipping it would have to extend or straighten and as it moves posterior it would have to flex.

The pelvis tilts forward during anterior thoracic cage translations while the lower lumbars flex and the upper lumbars extend. I had a hard time grasping this concept initially. That the lower lumbars would move into flexion as the upper lumbars extended in response to the anterior translation of the curve just didn't seem to make sense to me. As the motion starts with the thoracic spine moving forward and the spine is straightening and ending at the pivot on the femur heads, in order to minimize the tilt of the spine and to offset and balance the shift of weight forward, the spine must extend the upper lumbars. As the curve progresses caudally, the weight on the posterior element drives the lower lumbars into flexion, once again to distribute the weight.

The pelvis extends backward in the posterior thoracic cage translations and the lower lumbars extend while the upper lumbars flex creating an "S" configuration. Here, as the weight is transferred posterior, the pelvis tilts and the kyphosis increases, being primarily focused in the lower thoracic spine carries that motion into the upper lumbar spine. The lumbars, being designed for flexion/extension movements, easily flex and the upper and the lower lumbars compensate by moving into extension.

Comparing the displacement of T12 to the femur head there was approximately 85 mm anterior translation and 73 mm posterior translation. Having never thought about measuring this, I found it to be quite a bit more travel than I had thought. This is just over 6 inches of travel.

These studies were performed in "healthy" young subjects, all asymptomatic and not truly representative of what walks into our office but, if we are to assume that this is truly what is "normal", then there is quite a bit of relevance to what we see our offices.

First of all, the surgeons are getting wise as to the importance of the curves. Vialle et al said in 2005 *"Providing correct sagittal balance by surgical correction of a spinal deformity is of paramount importance. In the short term, it ensures a good position of the fused segment with regard to the gravity plumb line, allowing the best conditions for fusion. In the long term, good sagittal balance facilitates preservation of the adjacent levels."* They continue to say that "*there is a relationship*

between the pelvic inclination angle and the sacral slope, between the sacral slope and the lumbar lordosis, and between the pelvisacral angle and the pelvic inclination angle."

Since we are the best solution for spinal problems, we should probably be looking at the transition of the spine in the sagittal plane a bit more closely. Ideally there would be minimal translation anterior or posterior of certain landmarks in the spine. In order to conserve energy and maximize performance, it makes sense for the body to balance itself vertically. This should also minimize joint wear. I measure T12, C7 and the middle of the dens in relation to the posterior of the sacral base. Very rarely are all these three points anterior or posterior of the sacral point. These cases usually involve antalgia or severe spinal deformity. Often times one of these three points is aligned very closely to that sacral point.

Post films show a trend towards balance as subluxations are corrected. Clinically, the big takeaway from these papers is to look for what isn't there but should be.

When a patient presents with a hyperkyphotic thoracic spine, do they have a more shallow sacral base angle? Are the lower lumbars in extension and the upper lumbars in flexion? Have the spinal landmarks translated posterior in relation to the sacrum? If the thoracic spine is hyperkyphotic, is the sacral angle steeper and have those landmarks translated anteriorly? If not, why? The title of the first chapter in the *Gonstead Chiropractic Science and Art* is "*The Level Foundation*". We list the spine to the bone below, the foundation. We typically adjust the lowest segment first. But what if something above is causing compensation below? Is the subluxation in the thoracic spine causing a hypokyphosis that has led to an anterior shift of the thoracics and decreased lumbar lordosis and sacral angle? Is that why the lordosis has not changed despite "adjusting" the AS, In or ASIn?

More study of the sagittal curves and more distal affecters certainly is warranted. Looking outside of the changes from the norm as a possible cause or an effect will help the practitioner to improve their critical thinking skills, and their objective and subjective clinical outcomes.

—*Gonstead Chiropractic Science and Art*

—*How do anterior/posterior translations of the thoracic cage effect the sagittal lumbar spine, pelvic tilt and thoracic kyphosis?* Deed E. Harrison et al. European Spine Journal (2002) 11:287-293

—*Range of motion of thoracic spine in sagittal plane.* Daigo Morita et al Eur Spine J (2014) 23:673–678

—*Radiographic Analysis of the Sagittal Alignment and Balance of the Spine in Asymptomatic Subjects.* RAPHAËL VIALLE et al. The Journal of Bone and Joint Surgery Vol 87-A · Number 2 · Feb 2005 pages 260-267