Spinal mechanics

Describe in detail the normal movements of vertebral column:

- **Cervical spine:**

1. Flexion/ extension 60-75 degrees : it is greatest at atlanto-occipital junction, 13 degrees followed by C5-C7(high degenerative problems at this level)
2. Axial rotation : at C1-C2 50 degrees
3. Lateral bending coupled with rotation 10-12 degrees at C2-C5 then 4-8 degrees below C6 due to change in facet orientation from cranial-caudal orientation to coronal orientation (high incidence of subluxation at C7.
4. Anterior translation: 2-3 mm at C1-C2 limited by the transverse ligament.

- Atlanto-occipital joint: 13 degrees flexion/extension, 8 degrees lateral bending
- Atlantoaxial joint: 10 degrees flexion/extension, no lateral bending and 94 degrees rotation
- Thoracic spine :

1. Flexion/extension: 65-80 degrees (from T1-T5 -3 degrees per level and increases gradually at lower levels.
2. Lateral bending: 4-5 degrees per level T1-T10 and increases below the fixed rib cage to 5-10degrees per level. There is significant degree of coupling with axial rotation
3. Axial rotation: maximal at T4-T9. Axial rotation is limited in the lower thoracic spine because of the change in facet joint orientation from coronal to sagittal. Anterior translation is restricted by the coronal orientation of facet joints.

- Lumbar spine:

1. Flexion/ extension: 12degrees at L1 increases to 18 degrees at L5-S1.
2. Lateral bending: 7-9 degrees through all levels usually coupled with axial rotation
3. Axial rotation: 3 degrees per level.
4. Anterior translation of 2 mm is normal.

Describe the normal alignment of vertebral column:

- Cervical spine has **20-40 degrees of lordosis**, thoracic spine **20 degrees** of Kyphosis, lumbar spine 20-40 degrees of lordosis and sacral spine 20-40 degrees of Kyphosis.
- C1 articulates with occipital condyles (synovial joints) and C2 through 3 joints central odonto-atlantal and 2 lateral joints (lateral masses of C1 and articular processes of C2. C3-C7 is called subaxial cervical spine and articulation is through intervertebral discs and facet joints. The articulations are enforced by ligaments (apical, 2 alar, tectorial, ALL, PLL, lig. Flavum). **The facet joints are oriented in cranial/ caudal direction and changes to coronal plane at C7.**
- Thoracic spine is formed by 12 vertebrae that articulate through discs and facet joints (**coronal plane**) and enforced by ligaments as above. Rib cage serves to restrict motion and add stiffness.
- Lumbar spine :similar to thoracic
- Sacrum and coccyx: bony articulations : no disc

Discuss the factors responsible for stability of the spinal column:

- Stability of the spine means: the ability to produce normal pattern of movement under physiological stress so that there will be no pain, no abnormal movement and no neurological deficit. Instability = loss the spinal ability to produce normal pattern of movement under physiological stress which results in pain, pathological movement or neurological deficit
- Internal fixation =use of metal hard ware to stabilize the spine while fusion means use of bone graft with internal or external fixation or without fixation (Smith-Robinson). Spinal fusion can be instrumented and noninstrumented, anterior (interbody such as ALIF, PLIF ACDF, vertebrectomy and fusion) and posterior (interspinous, Intertransverse, Pedicle screw "3 column fixation)
- The factors responsible for spinal column stability are:

1. **Intact bony elements** in particular vertebral bodies, pedicles and facet joints.

A. The coronal orientation of thoracic facets prevents anterior translation. The sagittal orientation of lumbar facets limits axial rotation.
B. Rib cage restricts movements of thoracic spine and provides stability. For extension this reduction may be as high as 70%.
C. The anterior arch of C1 prevents anterior translation of C2

2. **Intact ligaments** :

A. **ALL**: extends from occiput to sacrum, composed of fibrous tissue, attached to the vertebral bodies and discs. The primary action is to prevent hyperextension and distraction. It's breaking load ranges from 50 newtons in the cervical spine to 600 newtons in the lumbar spine.
B. **PLL**: runs from the axis to the sacrum. The ligament strongly adheres to the disc annulus and marginally to vertebral bodies. It is ¼-1/10 the diameter of ALL. The primary action is to prevent hyperflexion. The tensile strength is 60-130 newtons in midthoracic region.
C. **Ligamenta flava**: runs from the ventral surface of upper lying vertebra to the dorsal surface of lower lying vertebra??. It is made of elastin 80% and collagen fibres. Tensile strength is greatest in **lower thoracic levels (300 newtons**). It looses elasticity with age .The amount of extension decreases from 70% to 30% in older subjects. Normally it can **decrease its length by10%during extension without buckling and can increase its length by 35% during flexion**
D. Capsular ligaments: attach to vertebrae adjacent to fact joints. They serve to limit joint distraction and to lesser degree to prevent anterior translation. Breaking loads are 150-170 newtons.
E. Interspinous and supraspinatous ligaments: these ligaments attach the spinous processes. . They serve to limit hyperflexion. The breaking point is 20-150 newtons
F. Intertransverse ligaments attach to transverse process. They limit lateral bending and axial rotation

3. **Intact disc**: annulus fibrosis attaches adjacent vertebral bodies. It blends with ALL anteriorly and PLL posteriorly.
4. Stability of the spine is affected to a lesser degree by the surrounding **muscles.**