Spine Sagittal Imbalance

1. Definition

Spine sagittal imbalance refers to a misalignment in the sagittal (side-to-side) plane of the spine, leading to postural disturbances, pain, and functional impairment. It is characterized by an abnormal anterior or posterior displacement of the head and trunk relative to the pelvis.

2. Key Measurements

Sagittal Vertical Axis (SVA): Distance between the C7 plumb line and the posterior superior corner of S1.

Normal: SVA < 5 cm

Imbalance: SVA > 5 cm (positive imbalance: forward displacement, negative imbalance: backward displacement)

Pelvic Parameters:

Pelvic Tilt (PT): Indicates compensatory retroversion of the pelvis.

Pelvic Incidence (PI): A fixed parameter that dictates lumbar lordosis.

Lumbar Lordosis (LL): Ideally, LL = PI ± 9° for a balanced spine.

Thoracic Kyphosis (TK): Normal range is 20–50°.

T1 Pelvic Angle (TPA): Combines PT and SVA to assess overall balance.

3. Etiology

Degenerative: Progressive loss of lumbar lordosis due to disc degeneration, facet arthritis, or osteoporotic fractures. Iatrogenic: Post-laminectomy kyphosis, flat-back syndrome following spinal fusion. Neuromuscular: Muscle weakness or imbalance (e.g., Parkinson’s disease, myopathies). Congenital/Developmental: Scheuermann’s kyphosis, congenital malformations. Trauma or Tumors: Pathological fractures or resection-induced deformities.

4. Clinical Presentation

Progressive stooping posture. Difficulty maintaining upright stance. Back pain, particularly in the lower lumbar and thoracic regions. Fatigue and impaired walking endurance. Neurological symptoms if spinal stenosis is present.

5. Compensation Mechanisms

Pelvic retroversion (increased PT). Knee flexion to shift the center of gravity. Hyperextension of the thoracic spine or cervical hyperlordosis.

6. Diagnosis

Standing full-spine X-rays (EOS or standard radiographs) for sagittal alignment analysis.

CT/MRI to assess structural integrity, stenosis, or underlying pathology.

Dynamic X-rays for flexibility and compensatory mechanisms.

7. Treatment

Non-Surgical Management Physical Therapy: Strengthening core, hip extensors, and paraspinal muscles. Bracing: In selected cases (e.g., elderly with severe kyphosis). Pain Management: NSAIDs, muscle relaxants, or injections for symptomatic relief. Surgical Management Indicated for severe imbalance, neurological symptoms, or significant disability.

Osteotomies: Smith-Petersen Osteotomy (SPO): Posterior shortening, useful for mild cases. Pedicle Subtraction Osteotomy (PSO): Removes a wedge from the vertebral body (often L3) to restore lordosis. Vertebral Column Resection (VCR): For severe deformities. Long-Segment Instrumented Fusion: Extending from the pelvis (iliac fixation) for stability. Minimally Invasive Techniques: Anterior column realignment (LLIF, ALIF) in select cases.

8. Prognosis & Complications

Good outcomes with proper realignment and rehabilitation. Complications include adjacent segment disease, pseudoarthrosis, implant failure, and coronal imbalance. Postoperative Rehabilitation: Essential for muscle reconditioning and maintaining alignment.

Conclusion

Spinal sagittal imbalance is a complex condition requiring a detailed assessment of spinal and pelvic parameters. Treatment ranges from conservative management to extensive spinal realignment surgery, depending on severity and symptoms. Advances in surgical techniques have improved outcomes, but proper patient selection and postoperative rehabilitation remain key factors in success.