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Spinal stability as defined by the three-column spine concept

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Summary. The three-column spine concept is supported by anatomical data from dry European and African skeketons, by experiments on fresh cadaver spines without chemical fixation and by an extensive clinical and surgical experience. There exists an axial and a transverse stability. Axial stability is maintained along a vertical column system : this consists of two columns at the C1-C2 level and three columns from C2 to the sacrum. The anterior column is formed by the vertebral bodies and discs, and the two posterior columns by posterior joints. Transverse stability at the motion segment levels is produced by a coupling of bony buttresses and ligamentous brakes. The three-joint motion segment is characterized by a triangular disposition of joints with opposing joint spaces, thus supporting the articular orthogonal triangulation concept. These observations have a clinical relevance in the field of spinal growth, changes consequent upon wear in spinal joints and clinical instability.

La stabilité vertébrale selon la théorie des trois colonnes

Résumé. La théorie des 3 colonnes repose sur des constatations anatomiques à partir de squelettes secs européens et africains, sur des études expérimentales à partir de rachis entiers cadavériques non fixés et sur de nombreux documents anatomo-pathologiques et cliniques. Il existe une stabilité axiale et une stabilité transversale. La stabilité axiale s'effectue grâce à un système de colonnes verticales au nombre de 2 en C1 puis de 3 à partir de C2 jusqu'au sacrum. La colonne antérieure est celle des corps vertébraux et des disques, les 2 colonnes postérieures sont celles des apophyses articulaires et des articulations zygapophysaires. La stabilité transversale au niveau des segments mobiles est assurée par l'action combinée de butées osseuses et de freins ligamentaires. La disposition triangulaire des 3 articulations de chaque segment mobile avec leurs interlignes à orientations opposées permet d'émettre la théorie mécanique de la triangulation articulaire orthogonale. Ces conceptions trouvent des applications dans la compréhension de la croissance axiale du rachis dans son adaptation à l'effort et l'apparition de lésions arthrosiques et enfin dans l'établissement de règles thérapeutiques pour les lésions instables des traumatismes rachidiens.

Key words : Stability - Instability - Spine

Stability of the spine is that quality by which the vertebral structures maintain their cohesion in all physiological positions of the spine.

Instability, or loss of stability is a pathological process which can lead to displacement of vertebrae beyond their normal physiological limits.

As compared to limb anatomy, spinal anatomy turns out to be more complex as regards joint morphology. This complexity in spinal morphology and architecture is the reason why its understanding is more difficult to gain. Following the first concept of spinal stability by Nicoll in 1949 [16], a lot of various stability theories have been proposed. Decoulx and Rieunau, in 1958 [5] pointed out that the "posterior vertebral body wall" was the mainstay of spine stability. Ramadier in 1963 [17] emphasized the role of the facet joint in stability. Holdsworth in 1963 [8] described the "posterior ligamentous complex" required to maintain spinal stability; the posterior ligament complex includes : supra- and interspinous

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ligaments, ligamenta flava, and posterior joint capsules. Roy-Camille in 1974 [18] reported that spine stability was maintained by the "middle segment" including the posterior wall of intervertebral disc and vertebral body, the pedicles and facets. Kirkaldy-Willis and Farfan in 1982 [9] defined instability as "the abnormal increased joint deformation with stress". For them the increased motion may become a severe clinical problem by reduction of the lateral nerve root canal and by central spinal stenosis; the primary lesions are located on the anulus fibrosus as a result of torsional stress and extend finally to facet joints. Recently Denis in 1983 [6] put forward a three column spine concept : the anterior spinal column is formed by the anterior half of vertebral bodies and intervertebral discs, the middle spinal column includes the posterior half of vertebral bodies and discs and the posterior longitudinal ligament, and finally the posterior column corresponds to the facet joints and the posterior ligamentous complex. In this regard, Denis proposed a physiopathological classification of severe spinal injuries with definition of unstable lesions.

In 1975 [10], I described a three-column spine concept, different from that of Denis. This theory was proposed to explain comprehensively what the other theories appeared to do only in part.

Materials and methods

Data from three separate disciplines support my concept of spinal stability. Firstly, morphological studies on dry skeletons, secondly biochemical studies on early taken cadaver spines without chemical fixation and finally, clinical data from various spinal diseases collected for twenty years.

Morphological studies

These were based on the study of a large number of skeletons of negroes and caucasians made in the department of Anatomy in Marseilles and Dakar (Senegal). Attention was given in particular to the architectural factors responsible in spinal stability.

Biomechanical studies

Ten cadaver spines were studied, all removed within 24 h after death and preserved in plastic bags at 4 °C. Increasingly extensive cuts were made in the intervertebral ligaments, capsules and discs to assess changes in segmental spinal mobility. Five cadaver spines were used to study ligament and disc resistance under shearing forces after cutting either the disc or the posterior ligamentous complex of three young and two elderly subjects. Dynanometers were used for measurements of forces applied to pairs of adjacent vertebrae.

Clinical studies

They were based on 20 years of spinal surgery, 5 in West-Africa (Dakar, Senegal) which permitted the accumulation of a vast number of interesting pathological cases. During the period in Africa one also had the opportunity to perform autopsy examinations on advanced spinal diseases (severe paralysis due to Pott's disease or spinal injury). Studies were also carried out on diseases affecting the spine in 14 children (spinal malformation, scoliosis, Pott's disease) in order to evaluate the effects of lesions on the growing spine. Finally, these clinical and anatomo-pathological cases provided interesting data towards understanding of unstable lesions and their consequences as related to neural structures and spinal growth.

Results : the three-column spine concept

It is necessary to consider spinal stability in both the vertical axis and the horizontal plane situated at right angles to the vertical axis.

Vertical axial stability (fig. 1)

In order to appreciate this, it is necessary to consider the morphology of the individual vertebrae and the structure of the spine as a single unit.

Vertebral morphology. From the atlas to the sacrum it is possible to identify those structures in the complex morphology of the vertebrae that resist the forces of gravity. The atlas can be likened to two lateral masses joined by two arches. The axis can be reduced to three pillars, a vertical conical pillar lying medially and anteriorly (dens and body) and two lateral oblique pillars. These three pillars are fused above in the body of C2 and diverge below, with respect to stability. The axis does not have true pedicles and the structures referred to as such are actually isthmuses or partes interarticulares, since they are interarticular structures. The structural features of C3 to L4 are analogous to those of the axis, i.e., these vertebrae are composed of three pillars : the anterior pillar formed by the vertebral body and the two pillars formed by the articular processes lying posteriorly. The three pillars are reinforced by horizontal bars, namely the pedicles and laminae. A similar configuration is found at L5 except that the vertebra is wedge-shaped and the posterior pillars are angled at the isthmic zones. The sacrum provides three points of support for the three pillars, i.e. the sacral base and two sacral facets. The weight-bearing forces are then transferred from the sacrum to the pelvic girdle by the two auricular surfaces.

Overall architecture of the spine. The juxtaposition of the various vertebral structures makes it possible to follow the lines of load-bearing forces from the cranium to the pelvis. The cranium transfers its weight to the spine through the two pillars of the atlas lying in the same coronal plane. The two pillars become three columns in the body of the axis, which is thus a veritable cross-road for the transmission of the forces. The forces are then transferred down the three colums, which are arranged in a triangle with an anterior apex.

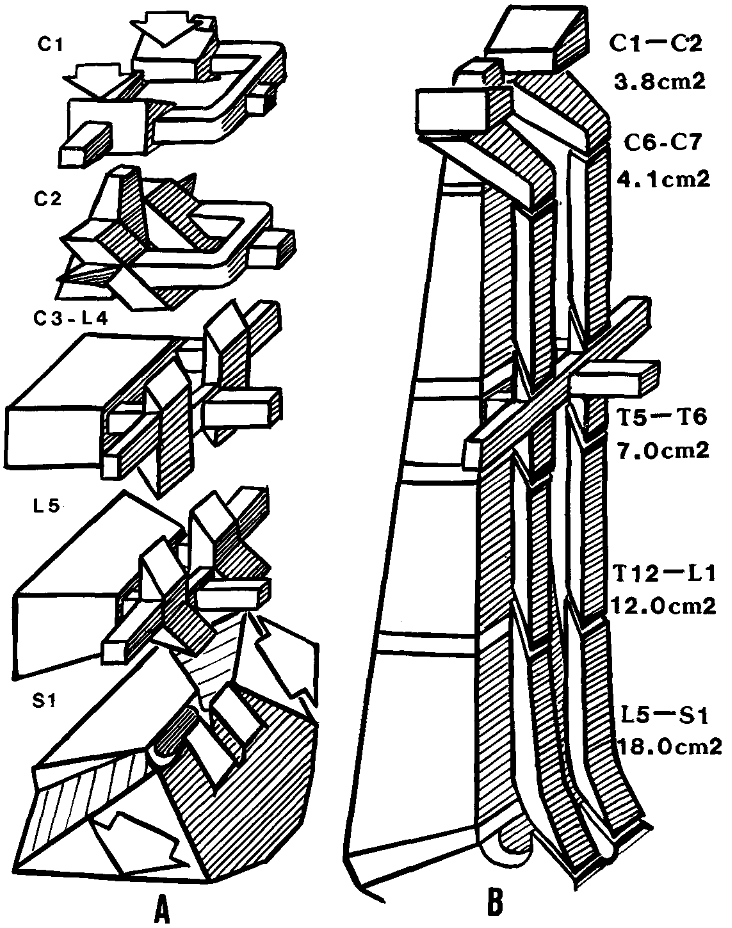

Fig. 1.
Illustrations of morphology of vertebrae (**A**) and overall architecture of the spine (**B**) showing the vertical columns which are two at the C1-C2 level and three columns from C2 to the sacrum. The total joint surface of a motion segment is increasing from the C1-C2 level to the L5-S1 segment (figures on the right)

Illustration de la morphologie vertébrale (**A**) et architecture d'ensemble du rachis (**B**) montrant les colonnes verticales au nombre de 2 en C1-C2 et de 3 de C2 au sacrum. La surface totale des articulations d'un segment mobile est croissante de C1-C2 à L5-S1 (chiffres sur la droite)

The larger anterior column takes on the aspect of a quadrangular pyramid formed by the alternating vertebral bodies and intervertebral discs down to the sacral base. The two posterior columns lying in a coronal plane are composed of the successive articular processes. At C2 and L5 these columns present an isthmic angulation. This may be one reason for the occurrence of spondylolysis in this region. The sacrum also constitutes a cross-roads of the descending forces, since it receives them at three points but transmits them to pelvis and lower limbs through two laterally placed sacro-iliac joints. This vertical system of columns is reinforced by horizontal struts which, at the level of each vertebra solidly joint the columns to each other. The struts are the two arches of C1, the posterior arch of C2 and the pedicles and laminae of the vertebrae lying below C2. The spinous and transverse processes do not participate in the system of spinal stability. Under static and dynamic conditions the spinal curvatures modify the axis of the vertical columns but in no way change the principles of axial stability. This three column structure of the spine, like a three-legged stool, provide the simplest and most efficient system of stability. This system also provides protection for the spinal cord and permits the exit of the segmental nerves at the intervertebral foramen.

Transverse stability (fig. 2)

When the spine is subjected to forces perpendicular to its axis, the points of weakness are located in the intervertebral motion segments. At any spinal level there are the same mechanisms to stabilize the spine : the coupling of bony stops and ligamentous brakes or in other words the articular orthogonal triangulation.

The coupling of bony stops and ligamentous brakes. Any extreme intervertebral motion is stopped by the coupled action of bony stops and ligamentous brakes.

During flexion : the bony stops or buttresses are, in the C1-C2 motion unit – the dens against the anterior arch, between C2-C3 and L5-S1 motion units – the articular processes and the anterior edge of endplates against each others. The ligamentous brakes are in the C1-C2 motion unit – the transverse ligament, the posterior atlantoaxial membrane and the articular capsules

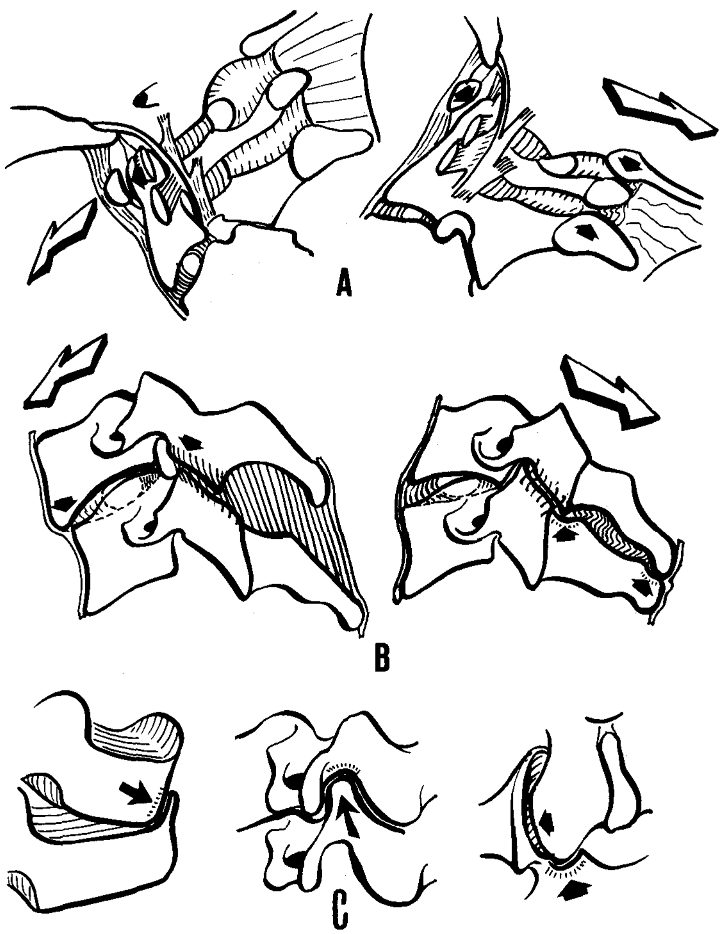

Fig. 2
Illustrations of the transverse instability of the spine during flexion-extension at the C1-C2 level (**A**) and the lower cervical region (**B**) and during inclination-rotation at the lower cervical region (**C** left and middle) and the lumbar area (**C** right). Dark arrows show the bony buttresses combined with ligamentous brakes for stabilising vertebrae during excessive motions

Illustration de l'instabilité horizontale pendant les mouvements de flexion-extension en C1-C2 (**A**) et au rachis cervical inférieur (**B**) et pendant les mouvements de latéroflexion-rotation au rachis cervical inférieur (**C** gauche et milieu) et au rachis lombaire (**C** droite). Les flèches noires montrent les butées osseuses couplées aux freins ligamentaires pour stabiliser les vertèbres lors des mouvements extrêmes.

of the lateral atlantoaxial joints; between C2-C3 and L5-S1 motion segments, the ligamentous brakes are all the ligaments located posterior to the nucleus pulposus, i.e. the posterior part of the anulus fibrosus, the posterior longitudinal ligament, the articular capsules, the ligamenta flava, and the inter- and supra-spinous ligaments.

During extension : the bony stops lie at the three angles of a triangle, i.e. the most posterior parts of the articular and spinous processes coming into contact with each other and laminae. At the craniovertebral junction, the bony buttresses are the anterior arch against the dens, the posterior arches and the occipital bone. The ligamentous brakes brought into play are those situated anterior to the nucleus pulposus, i.e. the anterior longitudinal ligament and the anterior part of the anulus fibrosus.

During inclination coupled with rotation : the bony stops are the articular processes, plus in the cervical spine the uncinate processes and the reciprocal pseudoarticulations between the lower surface of the cervical transverse processes and upper articular processes (fig. 2C). In the thoracic spine lateral inclination and rotation are considerably limited by the costo-vertebral joints, despite the facility of such movement afforded by the circular orientation of the articular facets in this region. In the lumbar region the sagittal aspect of the facets and the lateral margin of the end-plates are acting as bony stops. The ligamentous brakes are the intervertebral ligaments on the side opposite the tilt.

The articular orthogonal triangulation theory. Each mobile spinal segment is formed by a set of three joints located at each angle of a triangle and lying in nearly perpendicular planes. These three joints are the intervertebral disc and the two zygapophyseal joints. With the exception of the biarticular atlanto-occipital segment all the mobile spinal segments are triarticular. At each level the posterior articulations lie in a plane which opposes that of the intervertebral disc : this is approximately 45° in the cervical area, 60° in the thoracic region and 90° in the lumbar spine (Fig. 3). This concept also applies to the C1-C2 level where the median atlantoaxial joint is perpendicular to the lateral atlantoaxial joints. This configuration creates an orthogonal articular system whose mode of participation during effort differs

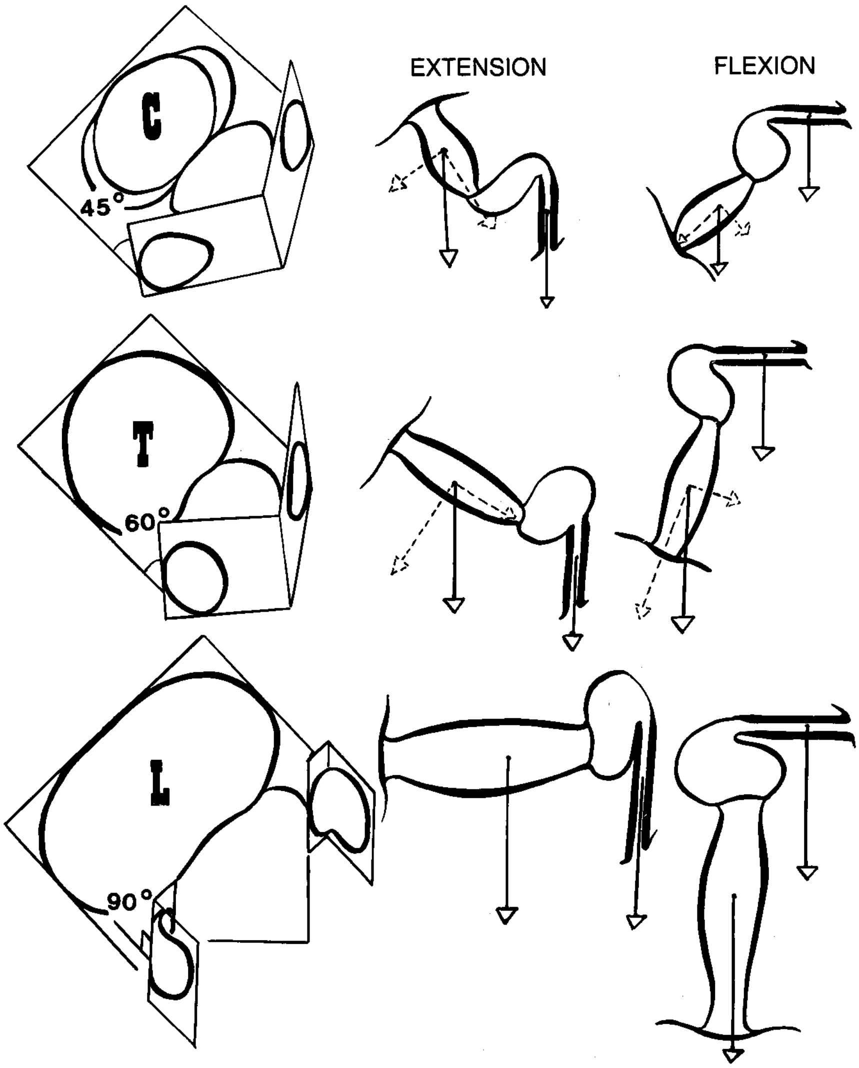

Fig. 3
Illustration of the articular orthogonal triangulation concept. On the left, upper view of the three joints of a cervical motion segment **(C)** a thoracic motion segment **(T)** and a lumbar motion segment **(L)**. At each level the posterior articulations lie in a plane which opposes that of the intervertebral disc : this is approximately 45° in the cervical area, 60° in the thoracic region and 90° in the lumbar spine. On the right : the cervical (upper), thoracic (middle) and lumbar (lower) motion segments are shown during extension and flexion of the spine. Arrows indicate the direction of weight-bearing forces acting upon the disc and the posterior joint. When the disc resist compression forces the posterior facets resist shearing forces and vice-versa

Illustration de la théorie de la triangulation articulaire orthogonale. A gauche vue supérieure des 3 articulations des segments mobiles cervical **(C)**, thoracique **(T)** et lombaire **(L)**. A chaque niveau, l'articulation postérieure se situe dans un plan qui s'oppose à celui du disque intervertébral : soit approximativement à 45° au niveau cervical, 60° au niveau thoracique et 90° au niveau lombaire. A droite, les segments mobiles cervical (en haut) thoracique (au milieu) et lombaire (en bas) sont étudiés dans les 2 positions, extension et flexion. Des flèches indiquent la direction des forces de pesanteur agissant sur le disque et sur l'articulation postérieure. Quand le disque est soumis à une force de compression, l'articulation postérieure résiste à des forces de cisaillement et vice versa

according to the orientation of the axis of the spine relative to the forces acting upon it. In the vertical position the forces of gravity and weight-bearing coupled with opposing muscular forces produce a compressive effect on the discs and a shearing effect on the posterior articulations. Conservely, when lifting a weight with the trunk in the horizontal position the different forces produce essentially compression of the posterior articulations and a shearing effect on the discs, although the required rigidity of the spine is nevertheless accompanied by an accessory effect of axial compression of muscular origin. Consequently, during the movements and efforts exerted by the spine, the posterior articulations share with the discs the bearing of the constraints applied to the vertebrae, thus there exists a modulated system of leverage involving these different structures. Accordingly, the total area of the discal and zygaphophyseal articular surfaces in each motion segment increases in the cranio-caudal direction to meet the increasing physical constraints. We calculated the mean total articular surface area at different spinal levels as follows : C1-C2 = 3.8 cm^2, C6-C7 = 4.1 cm^2, T5-T6 = 7 cm^2, T12-L1 = 12 cm^2, L5-S1 = 18 cm^2 (Fig. 1). Furthermore, the caliber of the flexor and extensor muscles of the trunk similarly increases caudally down to the gluteal muscles. Consequently the zygapophyseal joints should not be considered merely as being involved in the orientation of spinal movements, but also as weight-bearing structures subject to the pathological alterations of effort (sprain, spondylosis).

Discussion and clinical relevance

In this part the various theories on spinal stability will be discussed and the clinical relevance will be considered in relation to the development of the spine, adaptations to wear and spinal instability.

Critical review of existing concepts of spinal stability

The "posterior vertebral body wall theory" (Decoulx and Rieunau, 5) easily explains wedge-fractures and anterior damage of neural structures due to bone projection into the spinal canal. This theory, however, does not take into account the possible consequences of intervertebral ligament damage and subsequent bony displacement. By contrast, Holdsworth's theory [8] explains subluxation due to tearing of "the posterior ligamentous complex" but does not explain backwards subluxation resulting from a rupture of the anterior longitudinal ligament and the anterior part of the anulus fibrosus. This classification also passes over the unstable Chance fracture characterized by the horizontal section of the spine.

The "middle segment theory" of Roy-Camille [18] emphasizes some important factors of spinal stability such as the posterior wall of discs and vertebral bodies, the pedicles and facets. Despite an integrity of the middle segment, however, a coronal fracture of the vertebral body or a severe wedge fracture may unbalance the spine by progressive kyphosis. In addition, a posterior subluxation by tearing of the anulus anterior to the nucleus may be an unstable lesion.

The Denis' "three-column spine concept" affords a biomechanical explanation for many spinal injury lesions [6]. However, this theory is not supported by anatomical data but by anatomo-pathological and radiological investigations. The division of vertebrae into three parts appears somewhat artificial especially with respect to anterior and middle columns through the vertebral bodies. This theory does not explain why a normal spine is stable along its axis and how a motion segment maintains its stability during physiological movements.

Kirkaldy-Willis and Farfan [9] offer an excellent explanation for "instability in spondylosis". However the instability associated with spondylosis is not the same at that associated with fracture-dislocations of the spine. This concept challenges satisfactorily the usual mechanisms put forward by chiropractors, osteopaths and manipulators ("displaced vertebra", "subluxation" and "internal articular disorder"). Nevertheless the authors accept in the clinical instability concept both abnormal decrease or increase in the range of motion of a spinal joint. In my opinion the term "instability" must be kept only for abnormal increased motion and to cover both abnormal decreased or increased motion I prefer the term "disfunction".

The three-column spinal concept and spinal growth (fig. 4)

As a result of the three column spinal concept we state that a normal axial spine growth needs an harmonious growth of each column. In fact, some congenital anomalies of the spine (hemivertebrae, incomplete spinal blocks, lateral spinal bars) or some surgical excisions with fusion limited to one column, produce further increasing deformities due to the asymetric nature of spinal growth. The pathological region of the spine limits the growth rate of a column while the two other columns maintain their growth rate. Consequently the disturbance of growth leads to scoliosis, kyphosis or hyperlordosis.

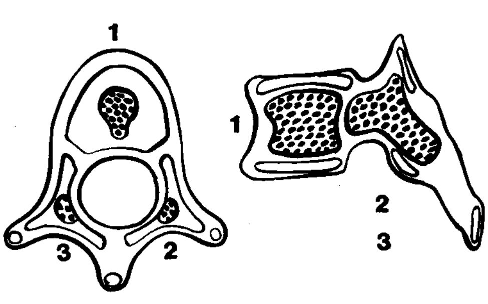

Fig. 4
Ossification pattern of vertebra. There are three single primary ossification centres : one for each vertical column of the three column spine concept

Disposition des points d'ossification primitifs de la vertèbre. Il existe un point d'ossification principal pour chacune des 3 colonnes de la théorie des 3 colonnes

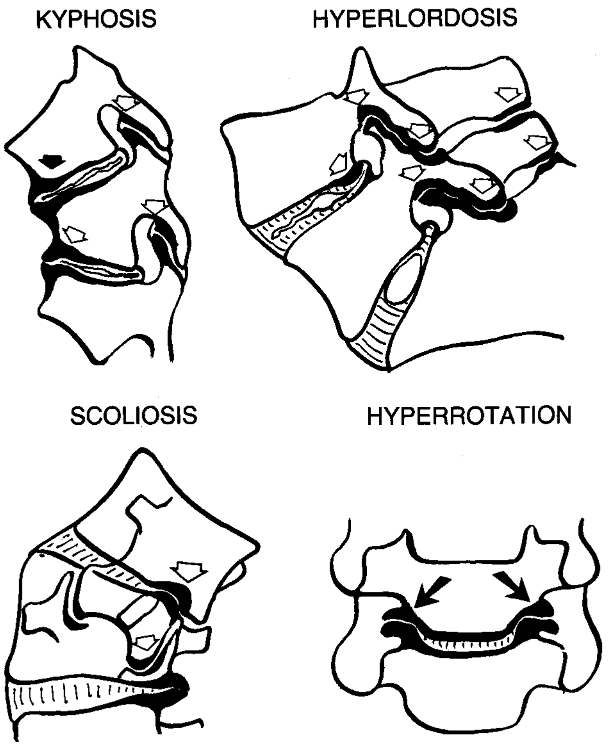

Fig. 5
Drawings showing how the spine adapts to wear in different conditions : hyperflexion or kyphosis, hyperextension or hyperlordosis and inclination-rotation such a scoliosis or uncarthrosis. Osteophytes, narrowing of the articular space, bony condensation appear where constraints are excessive at bony stop zones. In addition, stretched ligamentous brakes result in firstly spinal sprain, secondly spondylotic instability

Schémas montrant l'adaptation du rachis aux efforts dans diverses circonstances : hyperflexion ou cyphose, hyperextension ou hyperlordose et latéroflexion-rotation ou scoliose et uncarthrose. Les ostéophytes, le pincement articulaire, la condensation osseuse apparaissent sur les zones de butée osseuse soumises à des contraintes excessives. En outre, l'étirement des freins ligamentaires conduit dans une première phase à l'entorse vertébrale et ultérieurement à l'instabilité arthrosique

The ossification pattern of vertebrae supports my concept. Each column originates from a single primary ossification centre : the centrum for the anterior column and the two vertebral arch centres for the 2 posterior columns. As a consequence of this and to avoid deformity it is important when operating on the growing spine of a child to perform a symetrical fusion of all three columns for any limited disease requiring stabilization. A posterior fusion of the thoracic spine for scoliosis may be an exception to this rule provided the fusion is long and thick.

Adaptation of the spine to wear (Fig. 5)

My stability concept permits an understanding of constraints to which the spine is submitted : axial pressure along the three columns, pressure on the bony buttresses, the shearing effects on the ligamentous and discal brakes. When a joint acts in the extreme positions signs of early fatigue are usually noted. Subsequently, vertebral hyperflexion or hyperkyphosis increases the load on the anterior part of the intervertebral discs, the end-plates of the vertebral bodies and the superior part of the articular facets where osteophytes will be located. Hyperextension or hyperlordosis transfers forces towards the posterior arch and to the posterior part of the intervertebral disc. Thus it is not uncommon to observe signs of age-related arthrosis localised principally on the posterior articulations with zones of neocontact between normally distant structures, i.e. between the spinous processes, between the inferior part of the articular facets and the subjacent laminae, and between the superior part of the articular facets and the pedicular or isthmic regions. Lateral flexion with rotation or scoliosis increases the load on the lateral part of the discs, the intervertebral pseudo-articulation and the homolateral posterior articulation, with neocontact between the cervical transverse processes and the tips of the superior articular facets. At an advanced age, the deformity of scoliosis shows signs of arthrosis with dislocation due to shearing of the most horizontally inclined disc and arthrosis of the posterior articulation. Cervical uncarthrosis reflects a wearing of the cervical vertebrae in lateral flexion and rotation.

Spinal instability (Fig. 6)

My experiment on cadaver spines in 1976 [11] demonstrated that any instability with forward displacement requires at least a complete tear of ligaments and the anulus fibrosus posterior to the nucleus pulposus. A bilateral dislocation requires a complete division of all the intervertebral fibrous connections. The sectionning of one ligament, disc or facet does not produce instability, i.e. an abnormal displacement of a vertebra beyond the physiological limits. As a result of these biomechanical data and of anatomo-pathological observations I proposed in 1975 [10] an instability theory with classification of lesions in order to determine therapeutic indications (Fig. 6). Each vertical column ruptured is given a score of "+1", so the Chance fracture (slice fracture of the three columns in their bony structure) and the bilateral dislocation (horizontal shear through a motion segment) whould score "+3". The score for an incomplete lesion of the vertebral body and the fracture of pedicles or laminae are scored "+0.5". The fracture of transverse or spinous processes is scored "+0.25". The lack of

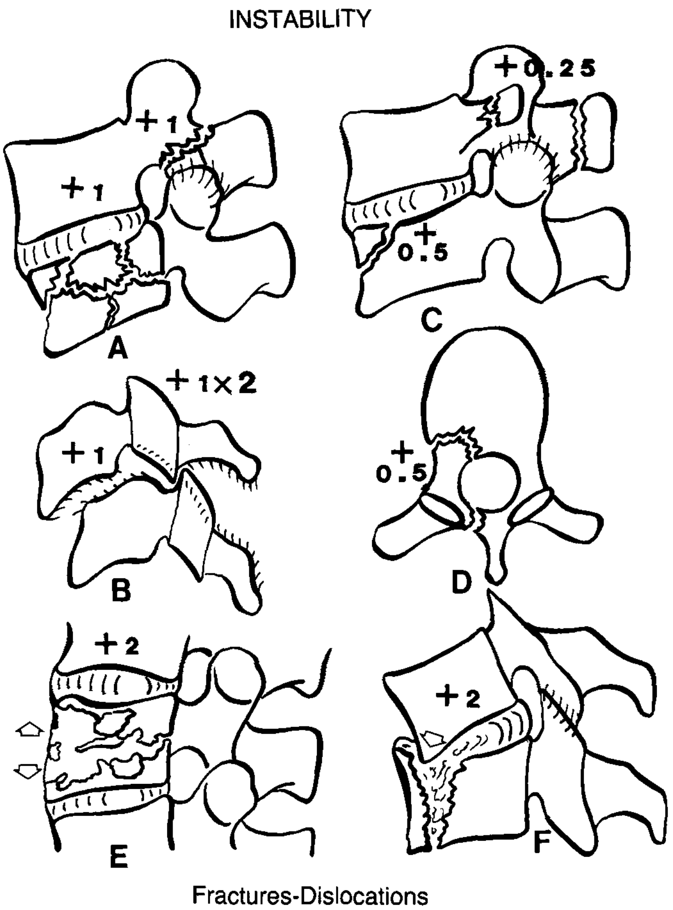

Fig. 6
Classification and scoring of severe traumatic lesions of the spine. Each vertical column ruptured is given a score of "+1" (**A, B**). The socre for an incomplete lesion of the vertebral body (**C**) and the fracture of pedicles or laminae is "+0,5" (**D**). The fracture of a transverse or spinous process is scored "+0.25" (**C**). The lack of substance of a vertical column is assessed as "+2" : Severe wedge-fracture after closed reduction (**E**) and coronal fracture of the vertebral body with tilt of the vertebra above (**F**). A lesion is unstable when the sum score is equal to or greater than "+2"

Classification et codification des traumatismes graves du rachis. Chaque colonne verticale rompue est évaluée + (**A, B**). Une lésion partielle du corps vertébral, une fracture pédiculaire ou laminaire est cotée +0,5 (**D**). La fracture d'une apophyse transverse ou d'une apophyse épineuse est cotée +0,25 (**C**). La perte de substance d'une colonne verticale est cotée +2 : c'est le cas d'une fracture cunéiforme sévère après réduction orthopédique (**E**) et celui d'une fracture frontale avec bascule de la vertèbre sus-jacente (**F**). Une lésion est instable quand le score total égale ou dépasse +2

substance in a vertical column is assessed as "+2". This is the case with severe wedge compression fractures that have been reduced by a conservative method; so the vertebral body substance contains several gaps which yield a recurrence of the kyphotic deformity despite prolonged immobilization. Otherwise, a coronal fracture of the vertebral body sometimes produces a loss of substance under the anteroinferior edge of the vertebra above, inducing automatically a further kyphotic focus. Consequently an unstable lesion corresponds to a score equal or superior to 2. Unstable lesions might be separated into 2 groups. Firstly a "temporary bony instability" such as Chance fracture for instance with bony lesions being likely to heal after reduction and immobilization without surgery. Secondly, a "permanent ligamentous instability" such as a bilateral dislocation involving ligament and disc lesions which are likely to yield weak scar so that surgical stabilization and fusion are advocated.

Spinal surgery with removal of lesions might alter the spinal stability. The lack of substance after surgery is evaluated in the same way as spinal injuries : "+2" for each damage vertical column. As a result reconstruction of each column is mandatory with bone grafts and internal fixation, especially by screw held plates in my practice. For some severe spondylolysthesis or total vertebrectomies for malignant tumors it is necessary to perform a reconstruction of the three columns by a combined approach.

Degenerative changes are likely to provoke instability but usually with moderate displacement (arthrotic spondylolysthesis). I think that the symptoms of the spondylotic instability described by Kirkaldy-Willis and Farfan [9] are also common to "spinal sprains" of the three-joint motion segments. These authors divide the spinal degenerative process into three stages (1) temporary dysfunction, (2) unstable phases and (3) stabilization.

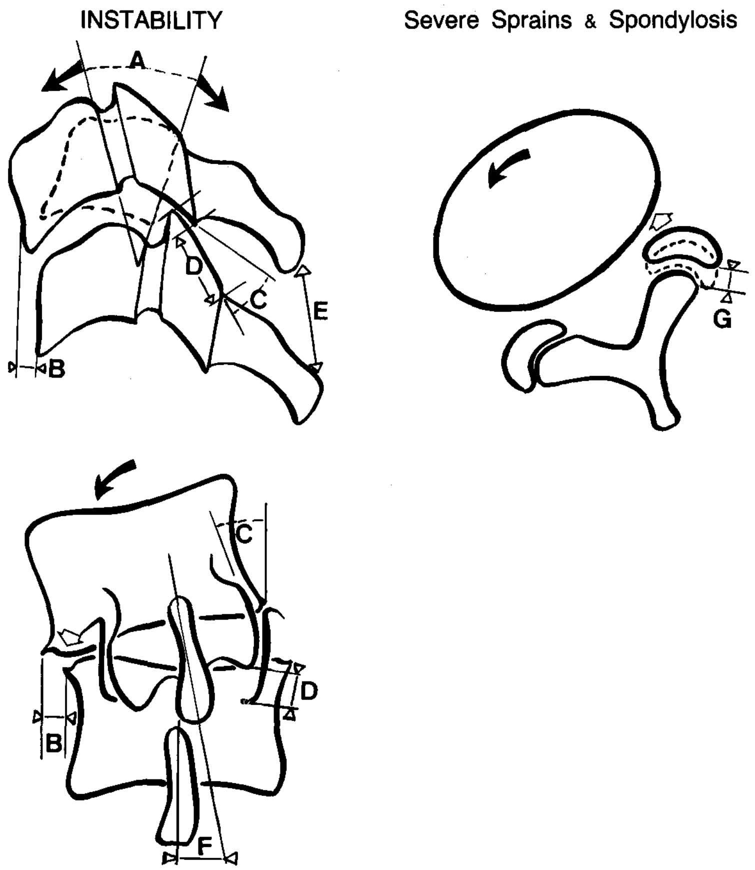

Fig. 7
Illustration of radiological signs of unstable lesions due to severe sprains or spondylosis. These are shown on lateral (upper left), **A-P** (lower left) and CT Scant (upper right) dynamic roentgenograms. These severe signs (from **A** to **G**) are separately sufficient to confirm instability due to disc and ligament loosening or rupture. **A** Antero-Posterior Motion superior to 11°. **B** Vertebral Body Translation C1-C4 sup. to 3.5 mm, C4-S1 sup. to 2.5 mm. **C** Loss of Parallelism. **C** Loss of Contact sup. to 50%. **E** Interspinous Widening. **F** Spinous Rotation. **G** Open Posterior Joint (Kirkaldy-Willis and Farfan, 1982)

Schémas des signes radiologiques des lésions instables par entorses graves ou arthrose. Ces signes sont vus sur des clichés dynamiques de profil (en haut et à gauche) de face (en bas et à gauche) et en coupe au scanner (en haut et à droite). Ces septs signes (de **A** à **G**) sont suffisants séparément pour confirmer l'instabilité par rupture ou relachement des disques et des ligaments

The history of patients suffering from spinal pain demonstrates that pain is preceeded by "spinal sprains" due to excessive or violent movements of some motion segments which can later lead to degenerative changes with fibrous and articular damage (Fig. 7). These lesions of the stabilizing factors (bony stops and ligamentous brakes) make the motion spinal segment work loose with progressive development of radiographic spondylotic signs. Dynamic radiograms using A-P and lateral projections are necessary to confirm this fact clinically. Lately Kirkaldy-Willis and Farfan proposed the use of CT scans in the diagnosis of instability. When there is an "increased motion the cartilage space increases on rotation and the superior articular process on that side is displaced forward to narrow the lateral canal" [9] (Fig. 7).

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