

# Anatomical and functional perspectives of the cervical spine:

## Part III: the "unstable" cervical spine<sup>†</sup>

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*In this, the last of the three part series on the anatomical and functional perspectives of the cervical spine, the clinical entity – instability – is addressed. A summative definition of instability, addressing both the clinical and radiographic issues, is presented based on current available literature. The etiology of instability is discussed as it pertains to three possible mechanisms: acute trauma, latent evidence of trauma and repetitive microtrauma. The anatomical, clinical and radiographic aspects in each of these mechanisms is discussed. A case report is presented to illustrate the salient features of this potentially disastrous condition. The conclusion emphasizes the importance of definable limits in each of the presented definitions, calling for future research into the clinical and radiographic correlations of abnormal cervical motion.*

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**KEY WORDS:** cervical spine, chiropractic, manipulation, instability.

In Part II of this series, we discussed excessive motion as it pertained to segmental hypermobility of the cervical spine; that is, excessive movement of a motion segment accompanied by local and/or peripheral symptoms not requiring invasive intervention. In Part III, we will explore the consequences of yet further increases in intervertebral motion, namely instability.

Authorities have regarded instability to be at the very end of the long continuum from normal to excessive motion.<sup>1,2</sup> Such excessive motion can arise in a variety of ways, including increased predisposition due to generalized hypermobility,

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*Dans cette dernière d'une série de trois études sur les perspectives anatomiques et fonctionnelles de la colonne cervicale, on aborde l'entité clinique-instabilité. On y présente une définition récapitulative de l'instabilité qui tient compte des questions cliniques et radiographiques et qui est basée sur la littérature disponible actuellement. L'étiologie de l'instabilité est discutée en tant qu'elle se rapporte à trois mécanismes possibles : traumatisme aigu, évidence latente de traumatisme et microtraumatisme répétitif. Les aspects anatomique, clinique et radiographique de chacun de ces mécanismes sont discutés. Une étude de cas est présentée pour illustrer les caractéristiques saillantes de cette condition potentiellement désastreuse. La conclusion met l'accent sur l'importance de déterminer des limites définissables dans chacune des définitions présentées, et souligne la nécessité de mener dans l'avenir des recherches sur les corrélations cliniques et radiographiques du mouvement cervical anormal.*  
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**MOTS CLÉS:** colonne cervicale, chiropratique, manipulation, instabilité.

acute and chronic traumatic events, and as a compensation for aberrant motion in adjacent segments. The exact point, however, where hypermobility ends and instability begins remains controversial. For chiropractors, this controversy impacts on the appropriate application of high velocity, short amplitude adjustments. Such treatment reflects an understanding that "Instability is more than a chronic disease . . .".<sup>1</sup>

In this, the last of the series, the elements of instability will be discussed. Further, the serious clinical and radiologic issues of this diagnostic dilemma, particularly concerning the lower cervical spine, will be examined.

### Segmental instability

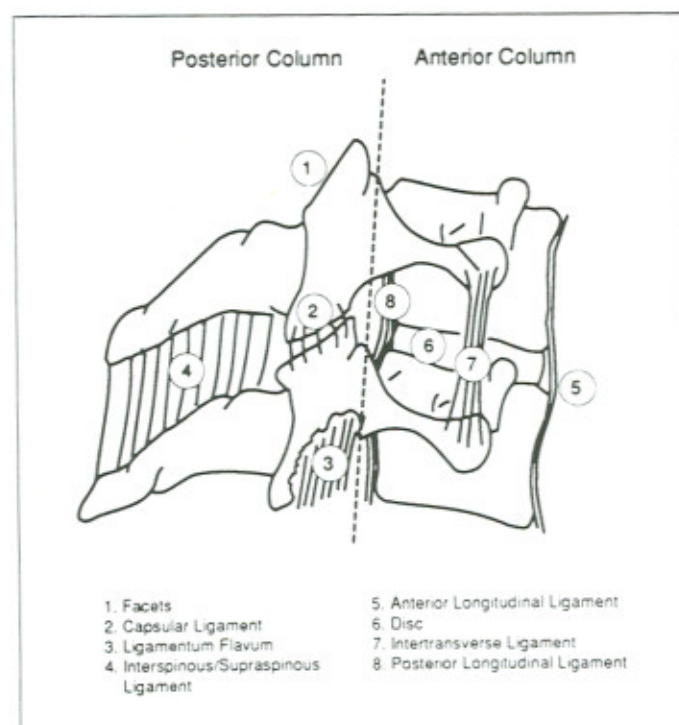
The concept of segmental instability concerns clinicians and surgeons alike. Although its implications in patient management, as we will review, are obvious, the definition of instability is not as clear. Like segmental hypermobility, segmental instability was defined by Schmorl and Junghans in 1971 as "a



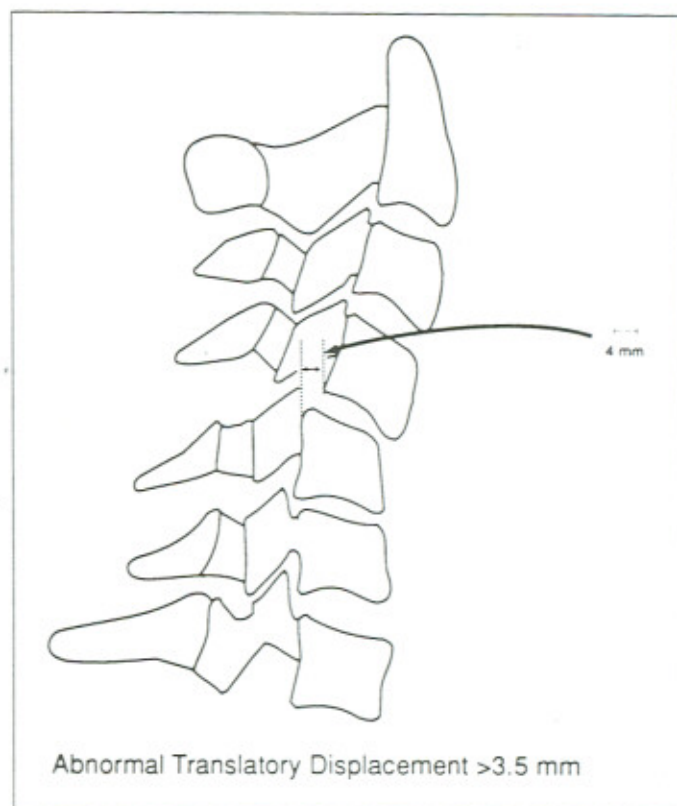
loosening of the mobility segment".<sup>3</sup> They believed this pathological entity to be the most common reason for the poor performance of two vertebrae and their associated tissues. Incorporating biomechanical principles, Farfan and Gracovetsky<sup>1</sup> referred to instability as "that (symptomatic) condition where in the absence of new injury, a physiological load induces abnormally large deformations in the intervertebral joint". Finally, in an attempt to integrate the many clinical, mechanical and physiological variables, White, Southwick and Panjabi<sup>4</sup> defined clinical instability as:

"the loss of the ability of the spine under physiologic loads to maintain relationships between vertebrae, in such a way that there is neither damage nor subsequent irritation to the spinal cord or nerve roots and, in addition, no development of deformity with excessive pain."

The degree of this spinal pathology reflects the extent of injury to the holding elements of contiguous vertebrae. White and his colleagues<sup>5</sup> consider a motion segment "unstable" if either all of its anterior or all of its posterior holding elements have been destroyed (figure 1). This is the point just prior to total failure of the segment. In experiments with cadaveric specimens, they found that the destruction of only one anatomical holding element in addition to the loss of either all of the anterior or posterior elements, caused the upper vertebrae in the



**Figure 1** Diagrammatic representation of the anterior and posterior columns of the cervical spine.



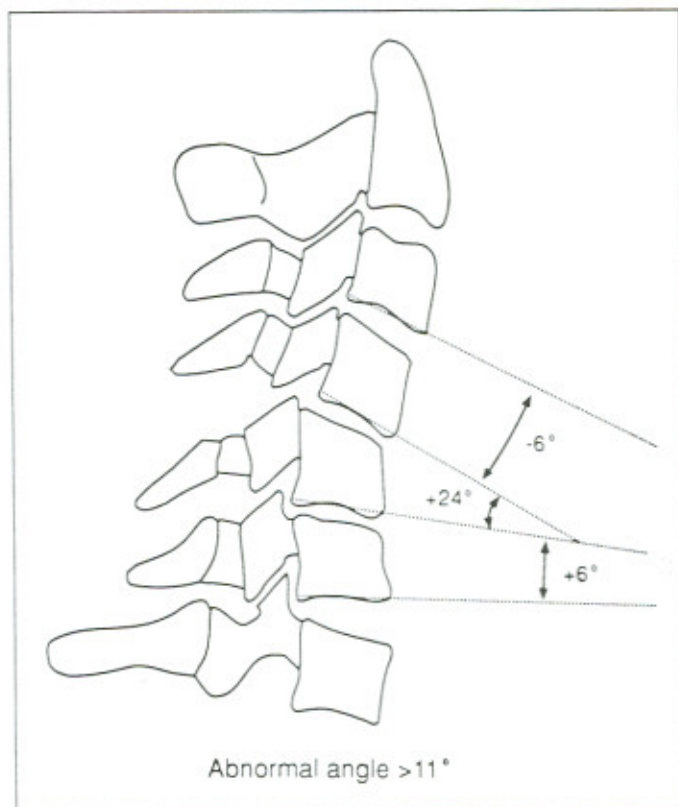
**Figure 2** Measuring the translation between one vertebra and another. Lines are extended perpendicularly from the endplates at the posterior-inferior aspect of the vertebra above and of the posterior-superior aspect of the vertebra below. The distance between these lines should not exceed 3.5mm. The measurement here is 4mm and is suggestive of clinical instability.

cervical motion segment to suddenly rotate 90 degrees or fly across the table when subjected to certain loads.

As a result of this work, White's group<sup>5,6</sup> set out the most comprehensive guidelines and criteria for the diagnosis of instability, which have been accepted and adopted by others.<sup>7,8,9</sup> Their criteria are scaled such that a score of five points or more is required for a segment of the cervical spine to be classified "unstable". The first item in the checklist is the status of the anterior elements. Two points are given if there is functional loss after such incidents as traumatic separation of the vertebral endplates, fracture, or disruption of the posterior longitudinal ligament either from surgery or from disease. The second item in the checklist is the loss of function of the posterior elements—given a further two points. This is expected with bilateral pedicle or bilateral facet and lamina fractures.

They also give two points for each of the two excessive sagittal plane movements measured from standardized x-rays.





**Figure 3** The difference in the angles formed by the intersection of lines extended from the endplates of two contiguous vertebrae should not be greater than 11 degrees. Here the difference between the angles formed at C3–C4 and C4–C5 is 30 degrees. This is suggestive of clinical instability at C4–C5.

The first movement is a translation of one vertebra upon another of greater than 3.5mm (figure 2). The second is an increase of 11 degrees or greater in the angulation formed by the intersection of lines extending from the inferior endplates of two adjacent vertebrae, when compared to the same measurements taken from one segment above and one segment below (figure 3). It is interesting to note that these figures are remarkably similar to those cited by Nachemson<sup>10</sup> in the lumbar spine for demonstrating instability of the segments in the lower back.

Points are also given for clinical demonstration of loss of segmental integrity. In a clinically experimental stretch test, increments of weight are added to cervical traction over time. In this test, under direct x-ray monitoring, the patient is evaluated for abnormal separation of one or more motion segments and/or for neurological symptoms. Two points are also given for obvious clinical signs of cord damage; while root damage, disc narrowing, and "dangerous loading anticipated" are each given

one. Although many authors refer to the aforementioned criteria, they frequently ignore the point values, choosing rather to only descriptively analyze the x-rays.<sup>7,8,9</sup>

In yet another attempt to radiographically quantify and define the presence of instability, Henderson and Dormon reported on the use of the ratio of displacement to sagittal body diameter in the cervical spine.<sup>11</sup> They concluded that a ratio of intersegmental movement greater than 0.69 in the male and 0.75 in the female is consistent with the diagnosis of instability. As previously explained,<sup>12</sup> these figures aid substantially in limiting problems of magnification, but such overall estimates do not account for the inherent differences at segmental levels, which may be very important.

In light of the information presented in the above review, and the definitions of "normal" and "hypermobile" given in Parts I and II<sup>12,13</sup> of this series, we define the endpoint of the continuum – clinical instability – as:

*The pathological state of motion at an intervertebral level in the cervical spine that results in clinically intolerable symptoms, as in cord or root damage, requiring prolonged bracing or surgery. Also involved are aberrations in neutral and/or flexion-extension x-rays, such as greater than 3.5mm translation and/or greater than 11 degrees difference in vertebral angulation.*

#### The current use of x-rays

It is apparent that most of the information in the literature regarding the substantiation of cervical vertebral problems has centred about the x-ray analysis of the patient. One of the most important radiologic assessments is the diagnosis of instability in a patient with cervical biomechanical abnormalities. However, of paramount concern is the accuracy and safety of this assessment. This varies with the mechanism of injury and the resultant clinical circumstances with which the patient presents, as described below.

#### Acute trauma

Acute traumatic injuries can occur in the cervical spine in a number of ways. Clearly in our society, immediate thought is centred around serious car accidents where impact can cause fractures and/or luxations of joints. Less frequent, but equally important, are the unusual traumas which may escape the clinician. One such case has been cited by Olin, Seligson and Schmidek<sup>14</sup> concerning the occupational hazard of "milker's neck". Unexpected movements by a cow, twice resulted in a compressive hyperflexion injury requiring surgical intervention. Similarly, "Porter's Neck"<sup>15</sup> has been described whereby porters in Rhodesia, routinely carrying 90.7 kg sacks on their heads, occasionally sustained serious compressive neck injury or even death due to inappropriate handling of the bags.

Of course the incidence for the injuries noted above is low. However, in dealing with any potentially serious situation, it has been frequently stated that after severe, acute injury involv-



ing the spine movement must be minimal, if allowed at all. This, of course, applies to the cervical spine, where severe injury can lead to the most disastrous sequelae.

It is emphasized by many of those addressing the issue of radiographic examination of the post-traumatic cervical spine, that the first x-ray taken is the lateral projection. They believe that the ramifications of most serious injuries can be recognized on this film alone.<sup>9,14,16,17,18</sup> Beyond simple strain-sprain injuries are those of complete ligamentous rupture and possible fracture. In general, compression and avulsion fractures will be obvious from this view.

Also important to note at the time the lateral film is taken are the radiographic indicators of cervical spine instability. Authors agree that serious instability will be apparent on flexion-extension films, but as neurological impairment may be increased with such movement in some patients during this acute phase, careful scrutiny of the neutral lateral may indeed reveal the problem and prevent the unnecessary risk of further testing. On the other hand, Panjabi et al. have recently suggested that lateral radiographs alone were unreliable in predicting instability.<sup>19</sup> This conclusion was based on a qualitative assessment of a post-trauma porcine spinal model.

Panjabi et al.'s conclusion is not consistent with that of Scher, who has described the radiographic signs of instability from the neutral lateral film.<sup>9,17</sup> Scher considered the appearance of an increased diameter of the precervical soft tissue an important indicator of instability. He suggested that this increase in diameter is due to hemorrhage associated with rupture of the anterior longitudinal ligament and disruption of the intervertebral disc, as seen in forceful extension injuries. Scher next referred to the divergence of the spinous processes and the acute kyphotic angulation of the vertebrae involved, as a sign of damage to the posterior elements. These latter two signs indicate posterior column disruption as seen in traumatic flexion injuries. Although opinion varies as to whether this angulation occurs in normal subjects,<sup>20</sup> where the correct position of the chin has been maintained, this kyphotic angulation must be considered radiographically abnormal.

Like Scher, Webb et al.<sup>21</sup> evaluated neutral lateral x-rays and described four major signs of instability resulting from acute flexion injuries. They also noted interspinous widening and the loss of cervical lordosis, but altered Scher's findings to include vertebral subluxation and compression fracture.

Agreement is thus widespread regarding the obvious structural abnormalities following acute trauma and the importance of a technically correct lateral cervical radiograph. In addition, it is apparent that flexion-extension films in these cases are not only dangerous, but if taken at all may, be inaccurate due to the soft tissue swelling and muscular spasm.<sup>9,16,18,22</sup>

#### **Latent evidence of trauma**

There are many reasons why initial x-rays of the cervical spine may not indicate underlying instability. These include technologically inadequate x-rays,<sup>22</sup> inappropriate views taken and

signs of instability that have been missed.<sup>21</sup> Further, in some cases, the initial x-ray examination is normal, but the patient deteriorates. Re-examination may reveal classic signs of instability.<sup>23</sup>

These latter cases have been referred to as "subacute instability" by Herkowitz and Rothman.<sup>7</sup> In their review of six cases, follow-up investigations performed an average of two weeks after essentially unremarkable initial evaluations, revealed dislocations and subluxations along with deteriorating neurological signs. They theorized that the injury leading to "subacute" or latent instability originally occurred within the elastic range of deformation of the vertebra and its holding elements. This may account for the initial observable absence of any bony displacement. Trauma to the elastic range is believed to result in continued stretching of the holding elements, until plastic deformation is achieved and bony displacement results.

Another theory for the normal appearance of the initial radiographs was put forward by Evans in 1976.<sup>24</sup> He wrote of the possibility that an initial bony displacement was spontaneously reduced by muscle spasm. Webb et al.<sup>21</sup> reported a similar belief in their case series on hidden flexion injuries of the cervical spine. Consequently, both authors recommended stress films under heavy sedation. The wisdom of this approach, however, is questionable.<sup>7</sup>

As stated earlier, technically adequate films are required to minimize error in determining the presence of instability. This is well illustrated in a case report by Nash,<sup>22</sup> where dark films resulted in missing the finding of precervical swelling. The patient subsequently developed a severe flexion deformity with late evidence of instability. In fact, even if adequate contrast had been achieved, the radiograph did not show C6 or C7, and the C5-C6 instability was actually beyond view.

Given the gravity of potential sequelae, it is recommended that follow-up x-ray examination for cervical trauma patients be done within three weeks to one month following the original injury. This is regardless of the reasons for further problems, or the small numbers in which they occur. The consequences of missing a lesion requiring surgical intervention would seem severe enough to warrant this precaution.

#### **Repetitive microtrauma**

Seemingly insignificant microtrauma can result in serious consequences to the patient, especially when coupled with other factors relating to damage and increased motion in the cervical spine. For example, Paley and Gillespie in 1986<sup>8</sup> presented a case report of C5-C6 instability in a female high jumper. In this case, the patient had suffered her original injury four years prior to presentation. She continued to incur repetitive flexion-rotation axial loading to her cervical spine during incorrect high-jump landings. Later she developed one episode of momentary paralysis after flexing her neck as she entered a pool, and another of loss of consciousness after hurting her neck in a shower. Resolution of the instability required surgery. The authors felt that the patient's mild generalized hypermobility



and the inherent mobility of the C5–C6 region may have contributed to the outcome of the case.

Others have addressed the question of whether events, such as cervical fusion, result in sufficient stress to the areas above and below the level of fusion to subsequently lead to instability. Dohler and his associates<sup>25</sup> did a cursory survey of 21 patients, an average of two years after anterior interbody fusions, and found that 14 of them did indeed have anterior displacement of a vertebra above the affected level. They found no relationship between this slippage (which they referred to as instability) and the patient's symptom state. Unfortunately, they did not define their criteria for the label "instability", and the number of patients used were too few to draw valid conclusions.

Not only may fusion result in increased motion above the involved segment, but this may also occur above an unstable one. In an in-vitro study, Goel et al.<sup>26</sup> observed an increase in the relative motion of segments above the instability they induced. They stated that the forces in the neck are transmitted through the apophyseal joints and the disc. As a result, they hypothesized that disruption of either of these structures will affect the motion behavior of the superior motion segment.

It is clear from both, experimental study and clinical observation, that the contribution of repetitive microtrauma in instability is highly complex. Both, inherent biomechanical factors and injury, play a role in how extensive this contribution is. Further research will be required before the relative risk of each contributory factor is understood.

### Case report

A 29-year-old female computer analyst presented with progressive left-sided neck and shoulder pain of three weeks duration. The onset was attributed to a fall while downhill skiing. She believed that she may have landed on her head and lost consciousness for several seconds. She felt an immediate sharp pain in her neck and noted a laceration on her face. She was taken down the ski slope by sled, without a collar, and taken to the local hospital. There, the laceration on her face was attended to, but her neck was neither examined, nor x-rayed. She spent the next several days of her holiday skiing and dancing. Although she continued to experience neck discomfort, she did not alter her lifestyle or her activities.

Upon presentation, she complained of a constant, dull ache which was worse in the morning and improved by late afternoon. The pain, first localized to the left side of her neck and shoulder, had progressed to numbness and tingling which extended to the elbow. The pain was aggravated by most movements and when she was lying supine. The arm pain was relieved by abducting the arm above her head. She noted no weakness nor other associated signs or symptoms. She was otherwise in good general health. She indicated no history of neck and arm pain.

Examination revealed a healthy, fit female in mild distress. Her head was listed to the left and positioned in slight flexion. There was apparent swelling in the area between C6 to T2,

extending laterally to both shoulders. The range of motion of the cervical spine was painfully limited by 20% in right and left lateral flexion, and by 50% in extension. Tenderness to palpation was observed at the levels C4 to C6 bilaterally, as well as in the associated paraspinal musculature. Deep pressure on the anterior aspect of the left side of the neck at C5 to C7, reproduced the distal left arm pain (doorbell sign). Neurological examination was unremarkable, except for a 4+/5 weakness of the left wrist extensors.

X-rays of the cervical spine were requested. The anteroposterior view revealed a left lateral list at C4–C5 (figure 4). On the lateral view, acute kyphotic angulation, interspinous widening, wedging of the discal interspace and precervical soft tissue swelling were seen at C4–C5. The anterior-superior endplate of C5 revealed sclerosis with slight compression. There was forward displacement of the facets of C4 on C5, i.e. subluxation



Figure 4 Anterior-posterior view of the cervical spine.



(figure 5). The difference in vertebral angulation between levels C4–C5 and C3–C4 was 28 degrees and between levels C4–C5 and C5–C6 was 18 degrees. On the flexion x-ray these increased to 33 degrees and 35 degrees, respectively (figure 6; tables 1 and 2). Of interest, measurement of the ratio of vertebral displacement and percent body diameter at C4–C5 as described by Henderson and Dormon, revealed ratios of .20 and .13 in flexion and extension, respectively.

A diagnosis of C4–C5 intersegmental instability was made. This was consistent with the score of nine obtained from White et al.'s criteria.<sup>5,6</sup> The patient was referred to the hospital where she was initially placed in halo traction and subsequently underwent surgery to fuse this area.



**Figure 5** Neutral lateral view of the cervical spine. Note the acute angulation, interspinous widening, and wedging of the interdiscal space at the level of C4–C5. There is also forward displacement of the facet i.e. subluxation. Intervertebral angulation was measured at 28 degrees.



**Figure 6** Flexion x-ray of the cervical spine. In this view, the vertebral angulation increased to 33 degrees. This is suggestive of instability of C4 on C5.

#### Discussion

This case illustrates the characteristic radiographic signs described above. Although the exact mechanism of injury is uncertain, the evidence strongly suggests disruption of the posterior column. The noted precervical soft tissue widening and minimal compression of the superior endplate of C5, indicates that the anterior column may also have been traumatized.

While the clinical signs and symptoms may not have initially been significant, her progressive deterioration should have

**TABLE 1**  
**VERTEBRAL ANGULATION**  
(in degrees)

Level	Extension	Neutral	Flexion
C3–C4	– 5	– 4	– 8
C4–C5	+20	+24	+25
C5–C6	+ 6	+ 6	–10
C6–C7	– 9	– 9	–13

**TABLE 2**  
**DIFFERENCE IN VERTEBRAL ANGULATION**  
(in degrees)

Between Motion Segments	Extension	Neutral	Flexion
C4–C5 and C3–C4	25	28	33
C4–C5 and C5–C6	14	18	35



raised the suspicion of a more sinister underlying pathology. Such pathology was evident on the neutral lateral cervical film taken at the time of presentation (figure 5). This film revealed the radiographic signs of instability at the level of C4–C5. The flexion-extension views revealed abnormal motion as evidenced by the differences in the measured vertebral angles (see Table 2), even though the ratio of displacement to percent sagittal body diameter was small. Thus reliance on the latter measurement would have been misleading.

This case illustrates the obvious importance of the appropriate diagnosis of instability in the cervical spine. The treatment required for this patient was immobilization. Any attempt to mobilize the neck would be considered dangerous.

### Conclusion

Parts I to III of this series propose that stability, hypermobility and instability are points along a continuum of cervical motion (figure 7). Segmental instability in the lower cervical spine (C2–C7) involves a series of clinical, biomechanical and physiological parameters. These parameters extend the concept of increased mobility of a motion segment discussed in Part II – Hypermobility<sup>13</sup> – to the point where referral for surgery or bracing is required. In an attempt to objectively delineate the diagnosis of instability, checklists of expected signs<sup>5,6</sup> and criteria for movement have been developed.<sup>11</sup> Clinical guidelines are currently available as to when and which cervical x-rays should be taken. Clearly, after an acute trauma, the lateral cervical projection is first taken to visualize the level of suspected segmental instability. While flexion-extension films may contribute to this diagnosis, movement may initially be limited and so incorrectly interpreted as not unstable. Furthermore, the potential hazards in taking these stress films following an acute trauma may outweigh the benefits.

Although many authors believe that in most cases information is obtained from the neutral lateral cervical film alone,<sup>9,14,16,17,18</sup> Panjabi et al. disagree.<sup>19</sup> After subjectively

assessing traumatized porcine cadaver specimens, they concluded that the neutral lateral x-ray film did not predict instability. Some credence is given to Panjabi's observation by the acknowledgement in the literature of the clinical entity – latent instability.<sup>7</sup> It is recommended, therefore, that cervical trauma patients, whose symptoms persist and/or progress, be re-x-rayed with the appropriate view three weeks to one month following injury.

Re-x-ray of a such a patient after an appropriate time seems logical. Difficulty arises, however, when one must clinically evaluate patients with chronic neck pain imposed by repetitive injury. Unfortunately, the role of repetitive microtrauma and lifestyle in promoting dangerously excessive lower cervical spine joint motion, is not well understood. Although a few case studies are available, the means of assessing the impact of repetitive microtrauma by x-ray or other diagnostic procedures is unavailable.

Larson<sup>27</sup> has called for the need for clinicians and radiologists to work together to understand the worth of routine screening tests, as well as specific tests for particular clinical situations. Certainly the clinical situation – instability – merits such study in order to provide the clinician with objective x-ray guidelines of clinically excessive motion that are not currently available.

In conclusion, segmental instability as an aberration of a motion segment is currently largely defined by the severity of its symptoms. Many of the diagnostic issues surrounding this phenomenon, however, have not been resolved. Given the potential catastrophic repercussions to the patient should this problem remain undiagnosed, clinical research involving symptomatic patients with a variety of lower cervical spine motion abnormalities is vital.

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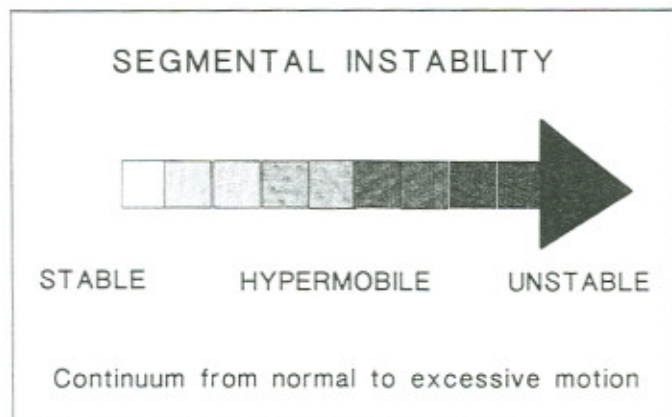


Figure 7 Cervical motion continuum.

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