Lumbar instability

37

CHAPTER CONTENTS

Although lumbar instability is considered to be responsible for the majority of chronic or recurrent backaches, the word 'instability' is still poorly defined. A number of different definitions exist, but as yet there are no clear and validated clinical features by which instability might be diagnosed. It is also not clear how instability as such might set up pain and disability.

It is generally accepted that instability does not cause trouble in itself, but predisposes to other conditions such as (recurrent) disc displacements, strain of the posterior ligaments and the zygapophyseal joints, and nerve root entrapment.

Definitions

At the most simple level, instability is a lack of stability, a condition in which application of a small load causes an inordinately large, perhaps catastrophic displacement.[1] This is also the description given by the American Academy of Orthopaedic Surgeons, who state: 'Segmental instability is an abnormal response to applied loads, characterized by motion in motion segments beyond normal constraints.'[2]

A biomechanically more accurate definition of segmental instability, using a 'neutral zone' concept, has been proposed by Panjabi. The neutral zone concept is based on the observation that the total range of motion (ROM) of a spinal motion segment may be divided into two zones: a neutral zone and an elastic zone (Fig. 37.1).[3] The neutral zone is the initial portion of the ROM during which spinal motion is produced against minimal internal resistance. The elastic portion of the ROM is the portion nearer to the end-range of movement that is produced against substantial internal resistance. Segmental instability is thus defined as a decrease in the capacity of the stabilizing system of the spine to maintain the spinal neutral zones within physiological limits in order to prevent neurological deficit, major deformity and/or incapacitating pain.[4] This definition describes joints that, early in range and under minor loads, may exhibit excessive displacement.

The clinical definition of instability is: 'a condition in which the clinical status of a patient with low back problems evolves, with the least provocation, from the mildly symptomatic to the severe episode'.[5] Others consider instability to exist only when sudden aberrant motions such as a visible slip or catch are observed during active movements of the lumbar spine or when a change in the relative position of adjacent vertebrae is detected by palpation performed with the patient in a standing position versus palpation performed with the patient in a prone position.[6]

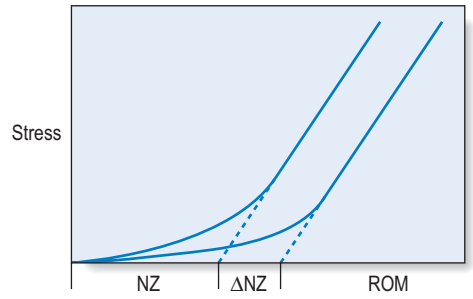

Fig 37.1 • In segmental instability, the stabilizing system is unable to maintain the spinal neutral zone (NZ) within physiological limits. ROM, range of motion.

Anatomy

In order to be clinically useful, the structures that are responsible for instability must be specified. The stabilizing system of the spine can be conceptualized as consisting of passive (inert) and active (contractile) parts and a neural control system.

Inert structures

The passive subsystem consists primarily of the vertebral bodies, discs, zygapophyseal joints and joint capsules, and spinal ligaments. The passive subsystem plays its most important stabilizing role in the elastic zone of spinal ROM (i.e. near end-range),[7] and numerous studies have been conducted that demonstrate the relative contributions of passive structures to segmental stability.

The posterior ligaments of the spine (interspinous and supraspinous ligaments), along with the zygapophyseal joints and joint capsules and the intervertebral discs, are the most important stabilizing structures when the spine moves into flexion.[8–11] End-range extension is stabilized primarily by the anterior longitudinal ligament, the anterior aspect of the annulus fibrosus and the zygapophyseal joints.[12,13] Rotational movements of the lumbar spine are stabilized mostly by the intervertebral discs, the zygapophyseal joints and, for the L4–L5 and L5–S1 segments, the iliolumbar ligaments too.[14]

Injury to the inert stabilizing system may have important implications for spinal stability. Intervertebral disc degeneration, weakening of the posterior longitudinal ligaments and early degeneration of the facet joints may increase the size of the neutral zone, increasing demands on the contractile subsystem to avoid the development of segmental instability.[3]

Contractile structures

The active subsystem of the spinal stabilizing system includes the spinal muscles and tendons and the thoracolumbar fascia; these contribute to stability in two ways. The first and lesser mechanism is to pull directly against the threatened displacement (which is, of course, not possible if the latter is a fragment of disc). The second, more important contribution is indirect: whenever the muscles contract, they exert compressive loads on the spine, which in turn achieves a stabilizing effect. In other words, by compressing joints in a neutral position, muscles may make it less easy for joints and discs to move.

During recent decades, a variety of studies have documented the stabilizing effect of muscles on the lumbar spine.[15–18] The lumbar erector spinae muscle group provides most of the extensor force required for many lifting tasks.[19] Rotation is produced primarily by the oblique abdominal muscles. The multifidus muscle seems to be able to exert some segmental control and is therefore proposed to function as a stabilizer during lifting and rotational movements of the lumbar spine.[20] The role of the oblique abdominal and transversus abdominis muscles in spinal stability has been the subject of much debate. The abdominals have been thought to play a stabilizing role, either by increasing intra-abdominal pressure or by creating tension in the lumbodorsal fascia.[21]

Box 37.1

Lumbar segmental instabilities: classification

1. Fractures and fracture dislocations
2. Infections involving anterior columns
3. Primary and metastatic neoplasms
4. Spondylolisthesis in children
5. Degenerative instabilities
6. (Progressive scoliosis in children)

Neuromuscular control

The neural control system may also play an important part in stabilization of the spine. Panjabi describes the stability system as being composed of an inert spinal column, the spinal muscles and a control unit.[22] In this model, changes in spinal balance resulting from position and load are monitored by transducers embedded in the ligaments that relay information to the control unit. When conditions that challenge spine stability are detected, the control unit activates the appropriate muscles to protect or restore stability, or to avoid instability. Evidence for this hypothesis is found in studies showing that patients with low back pain (LBP) often have persistent deficits in neuromuscular control.[23,24] This hypothesis was further supported by a recent electromyographic study demonstrating that a primary reflex arc exists from mechanoreceptors in the supraspinous ligament to the multifidus muscles. Such a reflex arc could be triggered by application of loads to the isolated supraspinous ligament, which in turn initiates activity of the multifidus muscles at the level of ligament deformation, as well as one level above or below.[25]

Classification of lumbar instability

The major categories of segmental instability are shown in Box 37.1.[26] Tumours, infections and trauma are beyond controversy. They produce mechanical weakening of the anterior

columns and can be diagnosed by medical imaging and by biopsy. Spondylolisthesis is a more controversial category. The condition is rarely progressive in teenagers or adults and can therefore be considered as stable in these age groups.[27] However, it has been suggested that concurrent severe disc degeneration at the level of listhesis may lead to progression of slip and convert an asymptomatic and stable lesion into a symptomatic one.[28]

More difficulties arise with respect to so-called 'degenerative instability'. The ageing of the lumbar spine has been discussed thoroughly (see Ch. 32). Grossly, it occurs in three sequential phases: dysfunction, instability and restabilization.[29]

During the early *phase of degeneration* (dysfunction), small annular tears and early nuclear degeneration appear in the disc, and ligamentous strains develop in the posterior ligaments and in the capsules of the zygapophyseal joints. The *unstable phase* includes reduction of disc height, gross morphological changes in the disc, and laxity of the spinal ligaments and facet joints. These changes lead to an increased and abnormal range of movement and to increased liability to disc displacements. During the *restabilization phase*, further physiological changes in the disc, such as increased collagen and decreased water content, together with the development of spinal osteophytes and gross osteoarthrosis of the zygapophyseal joints, result in increased stiffness of the spine and consequent stabilization (Fig. 37.2).

Biomechanical studies, both *in vivo* and *in vitro*, have confirmed this hypothesis: loss of stiffness, accompanied by annular tears or even nuclear disruption, has been reproduced in the laboratory by repetitive loading cycles which simulate normal human exposures.[30] In other experiments, load applications to degenerative segments have revealed loss of stiffness, sometimes with quite dramatic results.[31] However, difficulty remains in translating these anatomical and functional changes into clinical descriptions that could serve as a basis for diagnosis and treatment.

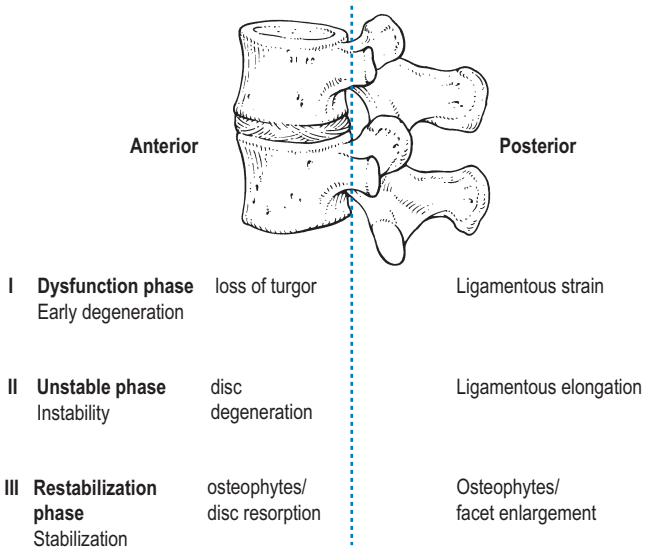

Fig 37.2 • The three sequential phases in the degenerative process of the lumbar spine.

A further classification system for degenerative lumbar instability (Box 37.2), based on a combination of history and radiographic findings, has been proposed.[32]

- *A primary instability* is one where there has been no prior intervention or treatment which might account for the development of the process.
- *A secondary instability* involves surgical destruction of one or more of the restraining elements of the spine. Secondary instabilities may develop after discectomies,[33] decompressive laminectomies, spinal fusions and chemonucleolysis.[34]

Rotational instability is still a hypothetical entity and so far normal radiological limits have not been identified.[35]

Translational instability is the most classic and best known of the primary degenerative instabilities. It is characterized by excessive anterior translation of a vertebra during flexion of the lumbar spine. At an early stage, it presents with disc space narrowing and traction spurs; later on, it represents degenerative spondylolisthesis. However, anterior translation is a normal component of flexion, and once again the difficulty that arises is setting a limit of normal translation. Many asymptomatic individuals exhibit anterior slips of more than 3 mm[36]; 4 mm of translation occurs in 20% of asymptomatic patients.[37]

Retrolisthesis develops when degeneration of the disc and the consequent decrease in disc height force the zygapophyseal joints into extension (see p. 442). Again, it has been shown that similar appearances occur in asymptomatic individuals.[38] Therefore, the simple detection of retrolisthesis on a radiograph is not an operational criterion for instability.

Instability and the clinical concept of mechanical lesions of the lumbar spine

Segmental instability is not painful in itself, and a patient with clear radiological signs of instability may be completely unaware

Box 37.2

Degenerative lumbar instabilities

Primary instabilities

- Axial rotational
- Translational
- Retrolisthetic
- (Scoliotic)

Secondary instabilities

- Post-disc excision
- Post-laminectomy
- Post-fusion
- Post-chemonucleolysis

of the condition. However, an unstable segment makes the spine more vulnerable to trauma; a forced and unguarded movement may be concentrated on the hypermobile segment and produce a posterior disc displacement. Repeated injuries may also lead to chronic irritation of posterior structures such as ligaments and zygapophyseal joints. An anterior or posterior shift of a vertebra may narrow the lateral recess to such a degree that the respective nerve roots become compressed.

Spinal instability is not a painful condition but may predispose to secondary lesions:

- Ligamentous sprain
- Recurrent discodural interactions
- Nerve root compression in a narrowed lateral recess.

Segmental instability and discodural interactions

It can be postulated that a hypermobile segment may predispose to recurrent disc displacements, leading to recurrent or chronic discodural interactions. Pain arises not from instability of the segment itself but from the instability of a fragment of disc lying within it.

The typical history is usually that of recurrent back pain, which begins either suddenly or gradually, depending on the consistency of the shifted fragment ('nuclear' or 'annular') (see Ch. 33, Dural concept). There are bouts of backache a few times a year, and between the attacks the patient is fit and the back is painless. However, the slightest sudden movement or unaccustomed posture leads to a new discal shift, resulting in a renewed discodural interaction and pain.

It is obvious that, in this case, not only should treatment address reduction of the displaced fragment of disc, but also treatment of the instability should be undertaken.

Segmental instability and ligamentous lesions

Postural ligamentous pain appears when normal ligaments are subjected to abnormal mechanical stresses (see Ch. 34, Ligamentous concept). This may occur during the dysfunction stage: some loss of turgor in the disc and the decrease in intervertebral joint space cause some laxity of the segment and an increase of the neutral zone. The facet joints override, with the upper articular processes sliding downwards over the lower. The joints adopt the extension position and the posterior capsules become overstretched. As instability proceeds, more tension is imposed on the ligaments and the facet joint capsules, leading to more postural ligamentous pain.

The patient is usually a young adult, who complains of diffuse backache with bilateral radiation over the lower back and the sacroiliac joints. The pain typically starts after maintaining a particular position for a long time and the intensity of the pain depends on the duration of this position. By contrast, there is absolutely no pain during activity or sports and all lumbar movements are free.

Segmental instability and the stenotic concept

Instability and the subsequent retrolisthesis may narrow the radicular canal and subsequently compress the nerve root (see Ch. 35, Stenotic concept). Usually, the process results from combined anterior pressure exerted by a buckled posterior longitudinal ligament and posterior compression of the superior articular process. The mechanism is as follows: considerable narrowing of the intervertebral disc space causes the posterior longitudinal ligament, which contains some fragments of remaining disc tissue, to bulge dorsally. This is especially the case in the standing or lordotic position. Because of the inclination of the facet joints, narrowing of the disc and increased laxity of the segment also result in retrolisthesis of the upper vertebra, which brings the nerve root in close contact with the tip of the anterior articular process of the vertebra below (Fig. 37.3).

The history is that of a middle-aged or elderly patient with unilateral or bilateral sciatica. The pain comes on during standing or walking and disappears on sitting or bending forwards.

Diagnosis of lumbar instability

The term 'segmental instability' is often misused and it has become fashionable to label any lumbar pain that is aggravated by movement as lumbar instability. The statement 'you suffer from lumbar instability' should be made sparingly, in that it is very hard to satisfy the criteria that justify use of this term. A diagnostic 'gold standard' for instability has not yet been identified.

Diagnosis is usually based on history, clinical examination, functional tests and imaging. Some elements can be found in the patient's history. It is believed that frequent recurrences of LBP precipitated by minimal perturbations, lateral shifts in prior episodes of LBP, short-term relief from manipulation and an improvement of symptoms with the use of a brace in previous episodes of LBP are confirmatory data for instability.[39]

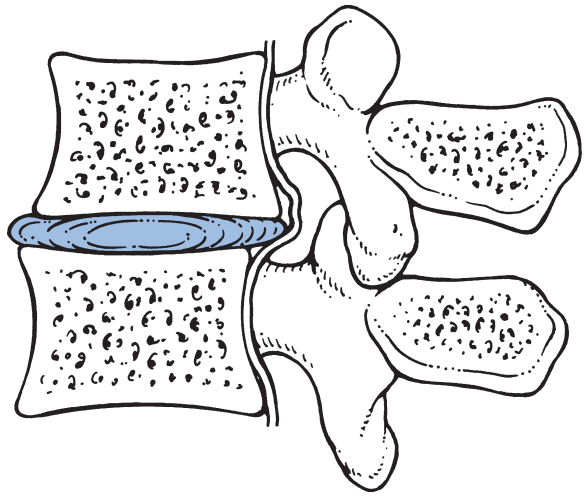

Fig 37.3 • Retrolisthesis narrows the nerve root canal.

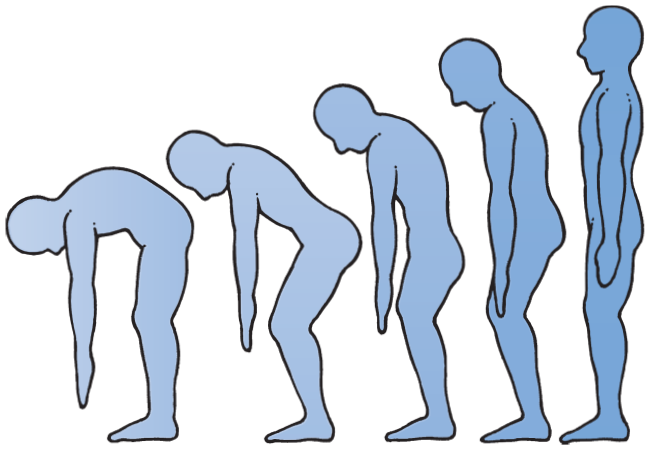

Fig 37.4 • Reversal of the normal spinal rhythm.

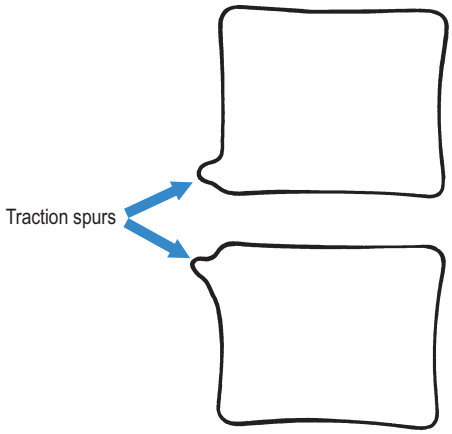

Fig 37.5 • Traction spurs.

Clinical observations

Some authors state that the palpation of increased mobility with passive intervertebral motion testing is indicative of instability.[40] The validity of these techniques, however, has never been demonstrated.[41] Others have proposed that aberrant motions such as the *instability catch* occurring during active ROM testing indicate instability.[6,42,43] The instability catch has been described as a sudden acceleration or deceleration of movement, or a movement occurring outside of the primary plane of motion (e.g. side bending or rotation occurring during flexion) and is proposed as an indication of segmental instability. However, this definition of an 'instability catch' is far too broad, because in the present description it also includes the common painful arc sign which indicates a momentary discodural interaction during movement (see p. 455).

In our opinion, MacNab's *reversal of the normal spinal rhythm* is much more characteristic of segmental instability.[44] In a normal lumbar–pelvic rhythm, there is a smoothly graded ratio between the degree of pelvic rotation and that of lumbar flattening. This rhythm may be disturbed in regaining the erect posture after forward flexion. In order to avoid putting an extension strain on the lumbar spine, the patient first slightly flexes the hips and knees in order to tuck the pelvis under the spine and then regains the erect position by straightening the legs (Fig. 37.4).

Radiological observations

Radiological measurements have been the most consistently reported method to establish instability, although again there is much controversy.

Disc space narrowing is a sign of questionable significance because this is a common age-related finding.

A second observation is the presence of traction spurs (Fig. 37.5), as described by MacNab.[45] The spur is considered to result from tensile stresses being applied to the outer annular fibres which attach to the vertebral body (see p. 444).[46]

The third observation is the presence of spinal malalignment. This radiological assessment is based on the early

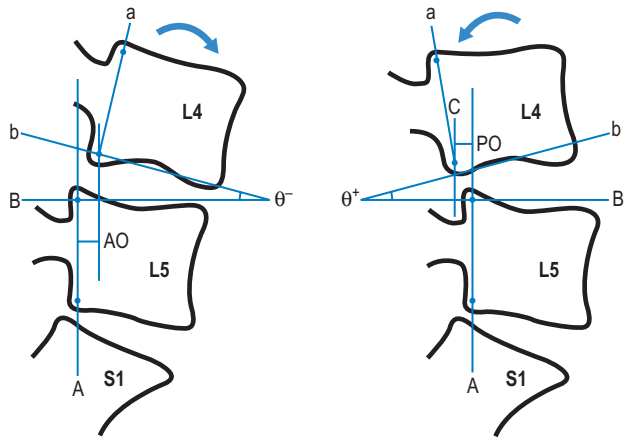

Fig 37.6 • Radiographic methods to evaluate anterior (AO) and posterior (PO) translation during flexion and extension (after Dupuis *et al*[50]).

observations of Knutsson, who defined instability as 3 mm or more of anterior translation measured between flexion and extension. However, as discussed earlier, there exists much debate about the upper limit of normal translations. Boden and Wiesel emphasized that any slip should be greater than 4 mm before instability could be considered.[36] Others concluded that a minimum of 4 mm of forward displacement was necessary at the L3–L4 and L4–L5 levels to define instability,[47] while at the L5–S1 level displacements of greater than 5 mm were necessary for accurate measurements (Fig. 37.6).[48,49] Furthermore, it has also been suggested that many instabilities do not occur at the extremes of flexion and extension, which is the usual technique utilized in routine radiographic studies.

Bracing

Lastly, it has been proposed that a trial of bracing should produce pain relief in a patient with instability. In general, the results have not been diagnostic, possibly because spinal braces usually produce little or no spinal immobilization.

Box 37.3

Diagnosis of lumbar segmental instability

History

- Chronic postural back pain and/or recurrent discodural interactions

Clinical examination

- Full range of movement
- No dural signs
- Reversal rhythm when regaining the erect posture from a flexed position

Radiography

- Traction spurs
- Anterior translation of more than 4 mm during functional radiographs

The diagnosis of segmental instability should be made sparingly. The features outlined in Box 37.3 may point to instability.

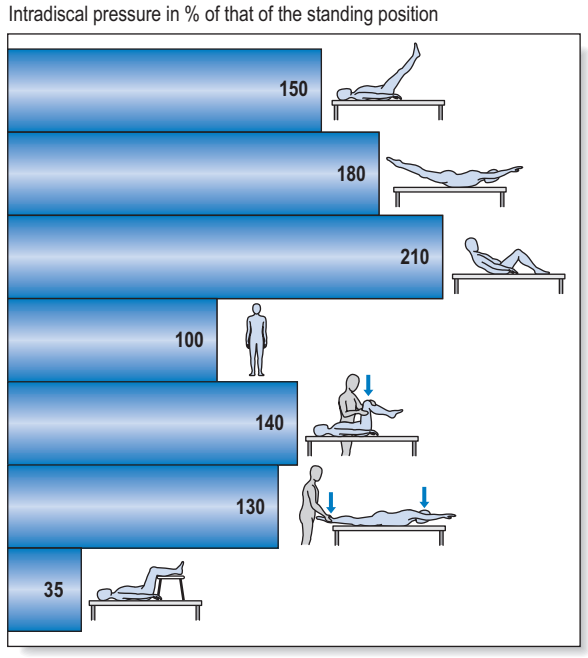

Fig 37.7 • Sit-up manœuvres may dangerously increase intradiscal pressure.

Treatment of lumbar instability

Patient education may be an important component in the treatment of patients with segmental instability. Education should, first of all, focus on avoiding loaded flexion movements, as they may create a posterior shift of the disc.[51] Patients should also be made aware of the importance of avoiding end-range positions of the lumbar spine because these overload the posterior passive stabilizing structures (see p. 583).

Physical therapy for segmental instability focuses on exercises designed (as is generally believed) to improve stability of the spine. During recent decades, all sorts of strengthening programmes have been designed for active stabilization of the unstable segment: the type of advocated treatment ranges from simple and intensive dynamic back extensor exercises to specific training of dynamic stability and segmental control of the spine.

As the lumbar erector spinae muscles are the primary source of extension torque for lifting tasks, strengthening of this muscle group has been advocated.[52] Intensive dynamic exercises for the extensors proved to be significantly superior to a regime of standard treatment of thermotherapy, massage and mild exercises in patients with recurrent LBP.[53–55] The abdominal muscles, particularly the transversus abdominis and oblique abdominals, have also been proposed as having an important role in stabilizing the spine by co-contracting in anticipation of an applied load. However, exercises proposed to address the abdominal muscles in an isolated manner usually involve some type of sit-up manœuvre that imposes dangerously high compressive and shear forces on the lumbar spine[56] and may provoke a posterior shift of the (unstable) disc (Fig. 37.7). Alternative techniques should therefore be applied when training these muscles.

Some authors strongly suggest that the transversus abdominis[57] and the multifidus muscles make a specific contribution to the stability of the lower spine,[58,59] and an exercise programme that proposes the retraining of the co-contraction pattern of the transversus abdominis and multifidus muscles has been described.[60] The exercise programme is based on training the patient to draw in the abdominal wall while isometrically contracting the multifidus muscle, and consists of three different levels:

- First, specific localized stabilization training is given. Lying prone, sitting and standing upright, the patient performs the isometric abdominal drawing-in manœuvre with co-contraction of the lumbar multifidus muscles.
- During the phase of general trunk stabilization, the co-contraction of the same muscles is carried out on all fours, and then elevating one arm forwards and/or the contralateral leg backwards, or on standing upright and elevating one arm forwards and/or bringing the contralateral leg backwards.
- Third, there is the stabilization training. Once accurate activation of the co-contraction pattern is achieved, training is given in functional movements, such as standing up from a sitting or lying position, bending forwards and backwards and turning. All daily activities are then integrated.

A significant result from a randomized trial has recently been reported comparing this exercise programme with one of general exercise (swimming, walking, gymnastic exercises) in a group of patients with chronic LBP.[61]

Despite the positive results with muscular training programmes, it remains difficult to understand how training of the lumbar and abdominal muscles can improve segmental

stability. Not only do the muscles (except for multifidus) have multisegmental attachments to the lumbar vertebrae, but also they are not very well oriented to resist displacements. Because they mainly run longitudinally, they can only resist sagittal rotation and are not able to resist anterior or posterior shears. However, whenever the muscles contract, and especially when they do this simultaneously, they exert a compressive load on the whole lumbar spine, as well as on the unstable segment. By compressing the joints, the muscles make it harder for the joints and for the intradiscal content to move.[62] The most important contribution of trained muscles to spinal stability may therefore be the creation of a rigid cylinder around the spine and increased stiffness.

It is important, however, for exercises to be prescribed as a means of prevention only after the actual problem – usually a discodural interaction – has been solved by manipulation, mobilization, traction or passive postural exercises.

Sclerosant treatment

Sclerosing injections given to the posterior ligaments are the conservative treatment of choice in segmental instability of the spine.

Therapy involves the injection of an irritant – phenol 2%, dextrose 25%, glycerol 15% – into the inter- and supraspinous ligaments, the posterior capsule of the facet joints and the deep part of the fascia lumborum at the affected level(s).

The infiltration produces a local inflammatory reaction, which is followed by increased proliferation of fibroblasts and the production of new collagen fibres. The final outcome is tightening, reinforcement and loss of normal elasticity of the connective tissue which decreases the mobility and increases the stability of the injected segments.[63–65]

The beneficial effect of this treatment method was recently shown in a double-blind controlled study that demonstrated a statistically significant difference between the active therapy group and those who received injections with a saline solution only.[66]

Technique

A series of infiltrations is made in all the dorsal ligaments at two consecutive motion segments (usually S1–L5–L4) and at the iliac insertions of the iliolumbar ligaments. Over 4 consecutive weeks, 3 mL of the solution, mixed with 1 mL of lidocaine 2%, is injected. The techniques are shown on page 918 but it is important to remember that, in order to steer clear of any vital structures, including those in the spinal canal, the injection should be made only when the tip of the needle touches bone.

- The first injection is at the interspinous and supraspinous ligaments.
- The second injection is given at the posterior capsules of the zygapophyseal joints.
- The third injection is given at the lateral aspects of the laminae, where the ligamentum flavum and the medial aspects of the deeper layer of the fascia lumborum merge.

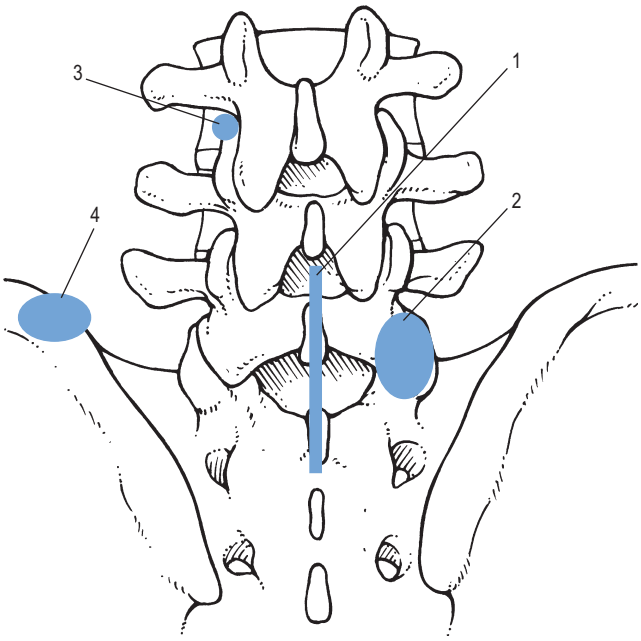

Fig 37.8 • Sclerosing injections in the treatment of segmental instability: 1, interspinous and supraspinous ligaments; 2, facet joint capsules; 3, deep layer of the fascia lumborum; 4, iliolumbar ligaments.

- The fourth injection aims at the insertion of the iliolumbar ligaments and the insertion of the thoracolumbar fascia on the posterior superior iliac spine (Fig. 37.8).

Surgery

The indications for spinal fusion in the treatment of degenerative instability are controversial. The basic problem lies, as discussed earlier, in the definition and the diagnosis of the disorder. However, despite the fact that indications for the procedure are uncertain, that costs and complication rates are higher than for other surgical procedures performed on the spine, and that long-term outcomes are uncertain, the rate of lumbar spinal fusion is increasing rapidly in the United States.[67,68] The rate of back surgery and especially of spinal fusion operations is at least 40% higher in the US than in any other country and is five times higher than in the UK.[69] Although there have been no randomized trials evaluating the effectiveness of lumbar fusion for spinal instability, the feeling remains that the operation should be reserved for patients with severe symptoms and radiographic evidence of excessive motion (greater than 5 mm translation or 10° of rotation) who fail to respond to a trial of non-surgical treatment.[70] The latter should consist of a combination of patient education, physical training and sclerosing injections.

Access the complete reference list online at **www.orthopaedicmedicineonline.com**

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