STRUCTURAL CHANGES IN THE LUMBAR INTERVERTEBRAL DISCS

Their Relationship to Low Back Pain and Sciatica

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In recent years it has become increasingly clear that one of the common causes of low back pain is disc degeneration. Though this fact is acknowledged by most clinicians, little is known about the pathological changes that occur, and much has still to be learned about the manner in which these changes cause symptoms.

Some help in understanding these problems has been acquired by examining the intervertebral discs in 123 lumbar spines excised at routine necropsies. After a preliminary radiograph of the cadaver and of the excised spine, a careful dissection was carried out. The supraspinous and interspinous ligaments were inspected. The neural arches were then removed and the posterior joints and ligamenta flava were examined in detail. The intervertebral discs after examination in situ were divided first horizontally and then vertically. Pieces of the discs, ligaments and posterior joints were subjected to histological examination. By this method of investigation it has been possible to obtain information on the anatomical, physiological and pathological variations that occur. The relationship of these changes to the radiographic appearance of the spine has been studied in detail in order to correlate the necropsy findings with the clinical picture of the low back pain syndrome.

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

The vertebrae are united by three joints: the intervertebral disc anteriorly, and the two zygapophysial joints posteriorly. The posterior articulations are simple synovial joints and exhibit all the gross anatomical features of synovial joints elsewhere in the body. The anterior part of the capsule is in close relation to the nerve root as it escapes through the intervertebral foramen and indeed the nerve root is occasionally found bound to the capsule by adhesions. This intimate relationship of the posterior joints to the nerve roots is of great clinical significance.

The detailed anatomy of the intervertebral disc and its attachment to the vertebral bodies is of importance in understanding the nature of the degenerative changes that subsequently occur. There are three main components intimately blended into a single functional unit: the hyaline cartilage plates, the nucleus pulposus and the annulus. The cartilage plates—On the cranial and caudal surfaces of the intervertebral discs are two plates of hyaline cartilage. These cartilage plates have three functions: they are the growth zone of the immature vertebral bodies (Fig. 1); they help to anchor the disc; and they act as a "barrier" between the nucleus pulposus and the spongiosa of the vertebrae. Up to the age of eight, the cartilage is penetrated by blood vessels passing from the vertebral body into the annulus and nucleus pulposus (Bohmig 1929) (Fig. 2). When these vessels are obliterated they leave a striated scar which interrupts the lamella of calcified cartilage. These scars represent structurally weak areas which may break down under stress, giving rise to microscopic herniations of nuclear material into the vertebral bodies. Through these microscopic herniations blood vessels may enter the disc from the spongiosa and give rise to some of the structural changes characteristic of an ageing disc. Occasionally large amounts

* Paper read by Dr Macnab at the combined meeting of the Orthopaedic Associations of the English-speaking World, in London, July 1952.
of nuclear material may escape through defects in the cartilage plates (Schmorl’s nodes). This loss of nuclear substance interferes with the mechanics of the joint. 

*The nucleus pulposus*—The nucleus pulposus in the growing disc is a viscid gel. It has a high water content and is very hygroscopic (Macnab 1948). The function of the disc as a whole depends to a large extent on these physical properties. Histologically the nucleus pulposus consists of a loose network of fine fibrous strands irregularly arranged, in the meshes of which are a few cells of variable morphology. A striking feature is the large amount of intercellular substance. The function of the intercellular material is poorly understood, but it probably plays an important role in facilitating the nutrition of the disc. With increasing age the intercellular substance decreases and this may play a part in initiating the degenerative changes.

*The annulus fibrosus*—There is no sharp dividing line between the nucleus and annulus. The annulus consists of lamellae of coarse collagen fibres running obliquely between the vertebral bodies. By careful dissection it can be shown that the direction of the fibres changes in the many layers that are present, and by so doing the fibres are better able to withstand the rotational stresses to which they are subjected. The attachment of the fibres of the annulus to the hyaline cartilage plate is of interest. The fibres ”stream” in obliquely and the direction of attachment can be followed deeply into the hyaline plate by the alignment of the cartilage cells (Fig. 3). The fibres of the annulus fibrosus fan out from their attachment to the cartilage plate and form into three groups. One group curves downwards to meet the fibres from below; one group passes outwards to blend with the longitudinal spinal ligaments; one group turns upwards and enters the vertebral body above the peripheral ring of bone. The peripheral bony ring fuses with the vertebral body at about the sixteenth year. When this occurs the annulus fibres are deeply imbedded into bone about three millimetres above the vertebral margins, this giving the disc a firm anchorage to the bone (Beadle 1931).

When the spinal column is divided longitudinally the nucleus pulposus protrudes. The observation has given rise to the statement that the nucleus pulposus possesses turgor. It is
doubtful, however, if this turgor is an inherent property of the nucleus. When an intervertebral disc is divided horizontally the nucleus does not protrude. This suggests that the protrusion of the nucleus seen on vertical section may in part be due to the unopposed contraction of

![Image](https://example.com/image.png)

**Fig. 3**

The histological appearance of the junction of the annulus to the hyaline cartilage. Notice how the annulus fibres are intimately blended with the hyaline cartilage plate, and the direction of the fibres can be followed into the cartilage plate by the alignment of the cartilage cells.

the remaining annulus fibres. This hypothesis has been tested experimentally. A spine was frozen and divided longitudinally. In the frozen state the nucleus does not protrude. Two adjacent vertebral bodies were transfixed in such a manner that no movement was possible between them. The spine was then allowed to thaw. Protrusion of the nucleus pulposus took place at every level except at the disc between the rigidly fixed vertebrae (Fig. 4). The "turgor" of the nucleus pulposus is largely due to the elasticity of the fibres of the annulus fibrosus which compress it.

One of the main functions of the annulus is to resist the displacement of the nucleus. The body weight compresses the nucleus pulposus and tends to reduce its vertical diameter and increase its horizontal diameter. This deformation is prevented by the annulus. In flexion of the spine the nucleus pulposus is displaced posteriorly and in extension it is displaced anteriorly. The annulus limits an excessive degree of such displacement. Experimental division of segments of annulus allows excessive movement in one direction, and removal of the nucleus through a small incision in the annulus permits an increased range of movement in all directions. These observations make it easier to understand the changes that are seen in association with disc degeneration. The annulus can be likened to a coiled spring, pulling the vertebral bodies and cartilage plates against the resilient resistance of the nucleus pulposus. The stability of the coupling unit depends on the integrity of all its components, damage to one of which will react adversely on the others. Loss of the nuclear substance by herniation into the vertebral body through a defect in the cartilage plate is equivalent to experimental extirpation of the nucleus and may result in excessive movements with consequent damage to the annulus, posterior joints and posterior ligaments. Desiccation of the nucleus can also give rise to abnormal movements and add to the damage sustained by the spine through a trivial injury. Similarly when the annulus fibres lose their elasticity they can no longer resist efficiently the deformation of the nucleus by the body weight or by
movement. If there is a uniform loss of elasticity throughout the annulus fibres or a decrease in volume of the nucleus the annulus protrudes around its circumference and the disc loses height. This will occur whenever the patient assumes an upright position. It is quite conceivable that a local loss of elasticity, a localised area of hyalinisation or a localised area of fibrous tissue replacement resulting from injury could give rise to a localised herniation of the nucleus pulposus.

**DEGENERATIVE CHANGES IN THE INTERVERTEBRAL DISCS**

The intervertebral disc reaches its greatest development at the end of the second decade. From then onwards structural changes of a retrogressive or degenerative nature become increasingly evident (Figs. 5 and 6). The ageing process is a complex phenomenon (Coventry et al. 1945, Päschel 1930, Beadle 1931) but it may be summarised by saying that it consists of a gradual inspissation of the disc associated with increasing conversion of the ground substance into formed elements. Associated with this there are brown degeneration and hyalinisation of all the components, metaplasia of the annulus into fibrocartilage, and destruction of the hyaline cartilage plate with microscopic herniation of the nuclear substance into the vertebral spongiosa.

Such variations can be properly regarded as the normal ageing process comparable with age changes seen elsewhere in the body. However, an intervertebral disc presenting the structural changes commonly found in the sixth decade could be described as a degenerate disc when found in a man of thirty. There is nothing specific about the pathological changes of so-called "disc degeneration" that distinguish them from the structural changes associated with increasing age. To avoid confusion the term "disc degeneration" will be retained in this paper to denote those showing either prematurely or to an exaggerated degree the structural changes of ageing, upon which may be superimposed the effects of injury.

When the structural changes of age occur prematurely during an active period of life, normal stresses and strains inflicted on the unstable segment may damage the disc severely.
The annulus may show tears running concentrically or more commonly radially. The radial tears may occur anywhere on the periphery, but they are most common posteriorly or postero-laterally (Figs. 7 and 8). Sometimes they are associated with an extrusion of nuclear material. Although these tears occur in an avascular area they are frequently haemorrhagic. The extravasated blood is derived from a concomitant injury to the cartilage plate, opening into the spongiosa of the vertebral body.

The posterior and postero-lateral tears are of clinical significance. In the region of such...
tears displacement of the nucleus is resisted solely by the weak posterior ligament. In the age group in which these tears are most frequently found, the nucleus has lost its gelatinous character and spontaneous extrusion is unlikely. However, even when the nucleus has become inspissated and contains many formed elements in its substance it is still displaced on flexion and extension of the spine. It is conceivable that a sudden unguarded flexion could give rise to extrusion of such a nucleus unprotected posteriorly.

Deposits of calcium are occasionally found in prematurely aged discs. Such deposits
are seen both in the annulus and in the nucleus and they may be either amorphous or granular (Fig. 9).

The nucleus of a degenerate disc commonly shows a brownish discoloration derived from blood pigments deposited as a result of minute haemorrhages from vessels that have grown through defects in the cartilage plate (Figs. 7 and 8). Severe injury to a degenerate disc may result in massive haemorrhage into the nucleus (Fig. 10). With constant and repeated injury fragmentation of the disc may occur (Fig. 11). The annulus fibres are shredded and the nucleus is barely recognisable, being represented by a few loose shreds of brownish tissue surrounding several cavities at the bottom of which can be seen the pitted cartilage plate.

**THE EFFECTS OF DISC DEGENERATION ON SURROUNDING STRUCTURES**

**The vertebral bodies**—A commonly observed radiological manifestation of disc degeneration is lipping or osteophyte formation of the vertebral bodies. Although our investigations lead
us to suppose that osteophytic lipping is related to disc degeneration in most instances, the clinical significance of vertebral lipping is not at all clear. This problem is the subject of an investigation being conducted at present. It seems probable that the importance of osteophytes lies chiefly in the fact that they denote not only the presence of disc degeneration but also the type of disc degeneration that has taken place and its effect on the stability of the involved segment.

The posterior joints—Degenerative changes in the intervertebral discs are generally associated with severe damage to the posterior joints. This relationship is partly coincidental; that is to say, senile changes will occur concomitantly both in the disc and the posterior joints. However, when severe structural changes are found in the disc of a young person, they are associated with correspondingly severe damage to the zygapophysial joints. The altered mechanics occasioned by derangement of one component of a spinal joint give rise to damage and degenerative changes in the other component.

![Fig. 11](image)

**Fig. 11**
Horizontal section of the lumbo-sacral disc showing marked disintegration. The annulus fibres are fragmented and there are many clefts in the substance of the nucleus pulposus.

In flexion and extension the nucleus pulposus acts as a ball-bearing; the vertebral bodies roll over this incompressible gel and the posterior joints guide and steady the movement. Once disc degeneration has occurred, the movement taking place between adjacent spinal segments becomes uneven, excessive and irregular.

It has been found by experiment that the axis of flexion and extension alters with every change in the arc of movement. In full extension the axis passes through the disc immediately behind the nucleus; in full flexion it passes immediately in front of the nucleus. The change of position is progressive throughout the movement and is compatible with the hypothesis that the vertebral bodies rock over the nucleus pulposus. In the presence of disc degeneration the behaviour of the axis is most irregular and unpredictable. The variability of the position of the axis is indicative of the irregular type of movement that is occurring. Occasionally the irregularity is so pronounced that it permits an antero-posterior shift of the vertebral bodies on flexion (Figs. 12 and 13) but more commonly it gives rise to a rocking or tilting of the cranial vertebral body. Sometimes with disc degeneration the axis of movement passes through the posterior joints and remains constant in position; when it does so, flexion and extension are associated with rocking of the posterior joints, giving rise to very severe damage (Figs. 14 and 15). It is partly the repeated trauma occasioned by these irregular movements
that initiates the degenerative changes which are seen in the posterior joints (Macnab 1950). The instability associated with some of these structural changes in the disc predisposes to fractures of the articular facets. The frequency with which such fractures are found suggests

Figure 12—Spondylolisthesis of L.3 on L.4. The radiograph has been taken with the patient holding the spine in extension. Figure 13—On flexion of the spine the body of L.3 moves forward on that of L.4.

Figure 14

Figure 15

Radiographs of the spine taken in full extension (Fig. 14) and full flexion (Fig. 15). Note how the posterior facet rocks open when the spine is flexed (patient of Dr H. M. Coleman).

that they may well be sustained as the result of trivial violence. Small chip fractures of the dorsal lip are not uncommon, and occasionally fissure fractures running right across an articular facet can be found (Figs. 16 and 17).

Disc degeneration can further damage the posterior joints by inducing subluxation. As
the intervertebral discs lose height the posterior joints tend to override. The capsule stretches and eventually the tip of the inferior articular facet impinges on the subjacent lamina. This evokes a bony reaction and a bony ridge which can be seen on the radiograph forms on the

pars interarticularis (Fig. 18). In extreme cases a hole may be worn right through the lamina at this point. (Fig. 19)

The earliest evidence of degenerative changes in the zygapophysial joints, whether associated with disc degeneration or not, is fibrillation of the surface of the articular cartilage.

Figure 16—The inferior articular facet from a fourth lumbar vertebra showing a chip fracture of the dorsal lip. In one view the osteochondral fracture has been displaced to show more clearly the extent of the lesion. Figure 17—An inferior articular facet from a third lumbar vertebra showing a fissure fracture running right across the inferior pole of the facet.

Figure 18—Posterior view of a lumbar vertebra showing a ridge of bone that has formed on the pars interarticularis, immediately below the superior articular facet of the fourth lumbar vertebra. This ridge of bone is formed at the site where the subluxated inferior articular facet impinges on the subjacent lamina. Figure 19—The lamina of the fourth lumbar vertebra. On the right there is a ridge of bone on the pars interarticularis, where the inferior articular facet of L.3 has pressed against the lamina; immediately lateral to this there is a hole where the superior articular facet of L.5 was impinging against the under-surface of the lamina. This type of change is seen with severe subluxation of the posterior joints.
When viewed obliquely in a good light, faint lines can be detected running across the normally smooth, pearly white surface. Later this streaking is exaggerated and the surface assumes a fine velvety appearance. This fibrillation of the cartilage increases and the surface becomes uneven and granular. At this stage it is common to find a "matting" of fibrous tissue covering portions of the articular cartilage. The cartilage becomes frayed, pieces flake off, leaving pits and occasionally osteochondral fractures of considerable size (Fig. 20). As in
other joints, these fragments of cartilage may form loose bodies which may lie entirely free in the joint or may become secondarily attached to the synovial membrane (Fig. 21).

These areas of cartilaginous erosion may give rise to the formation of intra-articular adhesions which vary from single filmy strands to a dense mat which precludes all movement (Fig. 22). Concomitant with the ulceration, the cartilage becomes heaped up around the edge of the joint giving rise to a corona—the precursor of the osteophytic outgrowths that are seen later. In the final stages of degeneration large areas of the articular surface are completely denuded of cartilage with exposure and condensation of the underlying bone.

Changes in the capsule accompany changes in the articular surfaces. The dorsal capsule thickens and frequently develops areas of cartilage within its substance. These vary in size from barely visible nodules to large masses protruding like beads behind and below the joint. These cartilaginous masses may be transformed into bone and this change is visible on the radiograph (Fig. 23).

There is nothing specific about the histological changes; they are similar to those seen in other synovial joints and follow the changes seen in the gross specimens. The first change is a tangential flaking of the surface cartilage.

The surface layers are lost and the vertical collagen fibrils running through the matrix become more prominent. The articular cartilage fissures through these lines and is seen under the microscope as long frond-like processes (Fig. 24). The chondrocytes lying in the
deeper layers become swollen, balloon-like, deeply staining vacuolated cells, lying in nests of six to twelve. Together with these changes a layer of fibrous tissue is occasionally seen on the surface of the cartilage which probably arises from metaplasia of the surface cells.

After this, the cartilage progressively loses depth by a process of attrition till bare bone is exposed (Fig. 25). Subchondral osteosclerosis, though common, is not invariably seen.

**Fig. 24**
Microscopic section of articular cartilage from a posterior joint showing early changes of degenerative arthritis. The collagen fibrils in the articular cartilage have become very prominent and vertical fissuring is occurring along the lines formed by these fibrils.

**Fig. 25**
Microscopic section showing the articular cartilage of a posterior joint with obvious degenerative arthritis. Most of the articular cartilage has been worn away. A few isolated fronds of cartilage cut in cross-section can be seen in upper part of the field. The bone underlying the cartilage shows marked condensation and most of the lacunae are empty.

Myelofibrosis and deposits of degenerate cartilage cells in the subchondral bone, however, are both frequently observed.

Disc degeneration, then, leads to severe changes in the posterior joints, and these joint lesions can, and do, give rise to symptoms.

**The posterior vertebral ligaments**—The posterior longitudinal ligament, the ligamentum
flavum, the interspinous and supraspinous ligaments all undergo degenerative changes which deserve a study in themselves. It is not the purpose of the writers to describe these in detail but merely to indicate briefly how degenerative changes in the discs might affect these structures.

The posterior ligaments act as checks to the movement of flexion. The abnormal movements allowed by disc degeneration add to the stresses and strains sustained by these ligaments. Because of the excessive amount of flexion permitted with a degenerated intervertebral disc, an unguarded or forced movement in this direction may severely strain or even rupture the supraspinous ligament. Scars of healed tears have been found in necropsy material and such lesions can also be recognised clinically (Newman 1952).

**THE RELATION OF DISC DEGENERATION TO SYMPTOMS**

Symptoms associated with disc degeneration may arise from the damaged disc itself. It has been shown (Hirsch 1948, Lindblom 1950) that the injection of saline into a degenerate disc can reproduce the symptoms complained of by the patient, and moreover at the time of laminectomy performed under local anaesthesia pressure on the disc gives rise to pain.

The disc may be the source of symptoms in those cases in which the annulus can no longer resist the deforming action of the body weight on the nucleus. When these patients assume the erect position the annulus bulges out around its circumference and protrudes beyond the vertebral bodies. A characteristic feature of the history is that the symptoms are aggravated by increase in the vertical weight loading of the spine—as for example when the elevator in which the patient is standing stops suddenly; conversely, immediate relief is gained when the compression forces on the spine are reduced—for instance by hanging by the hands from the top of a door or by lying down.

Though the disc itself may be the source of pain, disc degeneration more commonly produces symptoms by virtue of its secondary effects on the surrounding spinal structures—the paraspinal muscles, the spinal ligaments, the posterior joints and the nerve roots.

As has been noted, subluxation of the posterior joints is a common concomitant of disc degeneration. Every stage of degenerative arthritis, from fibrillation of the articular cartilage to complete disorganisation of the posterior joints, has been seen in association with degenerative changes in the disc (Fig. 26). Moreover the instability of the spine predisposes to fractures of the articular facets (Figs. 16 and 17).

If similar changes were found in any other articulation in the body it would not be surprising if the patient complained of pain on use of the joint. A sudden twist or strain
might give rise to an effusion, and it is not unreasonable to suppose that the locking of a loose body in an arthritic posterior joint could give rise to a sudden severe pain with locking of the back; the classical picture of lumbago.

Lesions of the posterior spinal ligaments and the posterior joints of the lumbo-sacral region can give rise to pain in the back, with referred pain in the distribution of the sciatic nerve. This can be shown experimentally (Kellgren 1939, Inman and Saunders 1944). Actual nerve root compression can also be produced by subluxation of the posterior joints with overriding of the articular facets. As the intervertebral discs lose height, the vertebral bodies approach one another. Owing to the common inclination of the posterior joints, the upper vertebral body moves not only downwards but also backwards, producing a retrospondylolisthesis. This displacement has several attendant dangers. The nerve root is displaced cranially into a very small space and comes to lie in close relationship to the capsule of the zygapophysial joint (Fig. 27). With further subluxation the related superior articular facet impinges against the nerve root (Fig. 28). The severity of the root involvement will be increased if at the same time there is the generalised bulging of the disc that occurs with uniform loss of elasticity in the annulus fibres. In such instances the horizontal diameters of the disc increase and it protrudes beyond the vertebral borders around its circumference ("the squashed" disc) (Fig. 29). Posteriorly the disc occupies all the space anterior to the superior articular facets and, by so doing, displaces the nerve root cranially. As the root escapes through the intervertebral foramen it is kinked by the lateral bulge of the disc and it may be buried in a deep furrow, indicating that it must have been under considerable tension (Fig. 30).

Probably the most common manner in which disc degeneration can cause root compression is by extrusion of the nucleus pulposus. In the 123 spines examined only four small herniations of nuclear material were seen; two of these were of the lumbo-sacral disc, one of the fourth lumbar disc and one of the disc between the ninth and tenth thoracic segments. The pathology
and the clinical aspects of the condition have been well covered in the medical literature, and the writers propose only to mention one feature of the pathology of the process that has an important bearing on treatment. Extrusion of the nucleus pulposus seldom occurs in normal discs. It is therefore commonly associated with damage to the posterior joints, which damage is likely to be further increased both by the operative trauma of laminectomy and the interference in the mechanics of the joint occasioned by the removal of the nuclear material. If the high post-operative incidence of back pain is to be reduced, steps must be taken to ensure that the damaged segment of the spine is stabilised either by adequate curettage of the disc space or by spinal fusion.

**Fig. 29**

Figure 29—A squashed lumbo-sacral disc protrudes beyond the vertebral borders both anteriorly and posteriorly. Anteriorly the protrusion has stripped up the periosteum from the front of the sacrum and from the front of the fifth lumbar vertebra, forming a subperiosteal spur. The original cortex can be seen lying deep to this spur. The pale areas in the bone immediately adjacent to the disc represent areas of bone sclerosis. The intervertebral disc itself is represented only by the thin white line on the photograph. **Fig. 30**—Diagram to show the changes associated with a "squashed" disc. The disc bulges out beyond the vertebral borders around the circumference of the vertebrae. It fills up all the space anterior to the superior articular facet, leaving a very small foramen out of which the nerve may escape. The nerve itself may be buried in a deep groove in the bulging disc.

THE RADIOLOGICAL DIAGNOSIS OF DISC DEGENERATION

The radiological picture of the later stages of disc degeneration is easily recognised. There are a narrowed intervertebral disc space, sclerosis of the adjacent vertebral margins and osteophytic lipping. The early changes require more careful study.

Evidence of degeneration early in the process can be obtained if the spine is radiographed in full flexion and full extension. Excessive flexion is permitted at the damaged segment and a certain amount of antero-posterior shift occurs on flexion and extension (Figs. 31 and 32). These changes are evident before there is significant narrowing of the intervertebral disc (Knutsson 1944). The instability of the spine revealed in this way indicates that the posterior joints are being subjected to great trauma and that the posterior ligaments stand in danger of strain or tear. If the flexion film shows marked separation of the spinous processes the supraspinous ligament may have been torn (Fig. 33).
Figure 31—Excised spine held in full extension. Notice that the intervertebral disc between L4 and L5 does not appear to be unduly narrowed. Figure 32—Same spine held in full flexion. An excessive degree of flexion takes place at L4 to L5. The anterior part of the disc is narrower than the posterior part—an unusual finding—and in addition a slight antero-posterior shift has occurred during flexion. This is probably one of the earliest signs of disc degeneration.

Figure 33—Spine radiograph in forced flexion. Notice the marked separation between the third and fourth lumbar spinous processes. There was a tear of the supraspinous ligament. Figure 34—Lateral view of the lumbo-sacral joint. A line drawn along the lower surface of the vertebral body normally cuts just through the tip of the superior articular facet of the vertebra below. In this radiograph the line cuts through the superior articular facet of the first sacral segment at a much lower level. Overriding of the posterior facets has taken place. Associated with this overriding there is retropseudylolisthesis of the fifth lumbar vertebra on the sacrum.
If lordosis of the spine is superimposed on disc degeneration, subluxation of the posterior facets may occur before there is any marked radiological evidence of narrowing of the intervertebral discs. Changes in the posterior facets are difficult to detect but there are a few radiological signs which, taken in conjunction with each other, are of assistance. In the lateral view of the spine the tip of the superior articular facet does not normally extend more than a few millimetres beyond the postero-inferior border of the vertebral body above. In extreme subluxation, the tip of the facet abuts against the pedicle of the vertebra above, and intermediate degrees of overriding may be recognised (Fig. 34). This is of particular value when differentiating congenital from acquired narrowing of the lumbo-sacral disc; acquired narrowing of this disc is always associated with some degree of subluxation. Retrospondylolisthesis and pseudospondylolisthesis in association with disc degeneration can be seen in the lateral projection. They indicate both damage to the posterior joints because of the overriding which has taken place, and also the possibility of nerve root compression within the intervertebral foramen. With the slightest degree of rotation of the patient or with poor centering of the film, these findings cease to have any significance.

In the antero-posterior view of the spine the smooth line described by the laminae, facets and transverse processes is interrupted by even minor degrees of subluxation (Hadley 1951). With more severe degrees of the change it can be seen that the tips of the dislocating facets become squared off and later the site of the impingement on the adjacent laminae can be recognised (Fig. 35).

The oblique projections of the lumbar spine are very useful. Malalignment of the articular surface can be seen and impingement of subluxated facets on the adjacent laminae is readily detectable (Fig. 36). With long-standing disc degeneration, arthritic changes in these joints may be recognised both in the antero-posterior and oblique projections.
CONCLUSION

One of the interesting aspects of spinal pathology having an important bearing on the treatment of backache is that the spine acts as an integrated whole and that damage sustained by one part frequently injures other structures in the spinal column. Thus disc degeneration may be associated with an extrusion of nuclear material; it may initiate degenerative changes in the posterior joints; it may predispose to tears of the posterior spinal ligaments; or it may give rise eventually to all of these lesions, any one of which may produce backache with or without sciatica. The sciatica may be referred pain or may be produced by nerve root pressure. Nerve root pressure in such instances is commonly due to an extrusion of nuclear material, but it may also be due to pressure on the nerve root within the foramen by a "squashed" disc or by a subluxated posterior joint.

Radiographs are of great value in the diagnosis of disc degeneration and they are of greater value in the assessment of the secondary effects that have taken place. With the use of bending films evidence of early degenerative changes may be obtained, tears of the supraspinous ligament can be detected, and abnormal movements of the posterior joints can be seen. Careful study of the antero-posterior and lateral projections will reveal evidence of subluxation of the posterior joints, chip fractures and degenerative arthritis in the zygapophysial articulations, and will clearly demonstrate overriding of the facets.

The investigation of subjective phenomena, such as backache, is fraught with many difficulties and it must be preceded by an investigation of the anatomy of the part and the anatomical variations, the normal and abnormal physiology and the pathological lesions that occur. Many of these changes of course may have no clinical significance, but it is only when armed with the knowledge of what may occur that we can tackle the problem of low back pain on a logical basis.

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