INDUCED PAIN PATTERNS ON PASSIVE STRAIGHT-LEG RAISING IN LOWER LUMBAR DISC PROTRUSION

A Prospective Clinical, Myelographic and Operative Study in Fifty Patients

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Passively raising the straight leg is a clinical test widely used in orthopaedic practice for the assessment of lower lumbar disc protrusion. Forst first described the manoeuvre in 1881 after his attention had been drawn to it by Lasègue (Sjöqvist 1947, Rang 1966, Brody and Wilkins 1969). Fajersztajn (1901) added the foot dorsiflexion test and neck flexion test, which are performed with the leg elevated and are positive when pain on straight-leg raising is aggravated. He also described the cross sciatic reflex or well-leg raising test (Woodhall and Hayes 1950). These tests are closely related to the Kernig's and Brudzinsky's sign found in meningeal irritation (Brody and Wilkins 1969). The biomechanical effects of straight-leg raising on the lumbo-sacral nerve roots and dura mater have been fully investigated by a number of workers, both in cadavers and in patients undergoing operation (Inman and Sanders 1942; Falconer, McGeorge and Begg 1948; Charnley 1951; Day and Hinchey 1962; Goddard and Reid 1965). However, the cause of limitation of straight-leg raising is not well understood. Although it is known that passive straight-leg raising may induce leg pain, back pain or a combination of both (O’Connell 1943, Hanraets 1959, DePalma and Rothman 1970), the significance of this is not clear.

The purpose of this study was to investigate the patterns of pain on passive straight-leg raising in established cases of acute lower lumbar disc protrusion and to relate these to the point at which the protrusion impinges on the dura mater and nerve root.

MATERIALS AND METHODS

Fifty patients were studied over two years. All patients had a history of acute symptoms and the location of disc protrusion was subsequently confirmed at operation.

The study was performed prospectively, and the clinical and myelographic features were correlated with the operative results in three parts. The clinical study entailed the taking of a history in which the duration and distribution of symptoms were noted. Patients with pain lasting more than eight months were arbitrarily excluded from the series. Clinical examination included the straight-leg raising test and neurological assessment of the lower limbs. The straight-leg raising test was carried out with the patient supine, the head being supported by a small pillow. The leg affected with sciatica was raised passively, with the patient relaxed and the knee in full extension. One hand was placed on the anterior superior iliac spine to judge the point of leg raising at which the pelvis started to rotate with flexion of the lumbar spine. (This is in contrast with Forst’s original description in which one hand was placed on the knee to keep it extended.) Elevation of the leg was stopped when the patient began to feel pain, and the angle of elevation and the amount of pelvic movement were recorded. The patient was then asked to indicate the distribution of pain and paraesthesiae. With the leg in the raised position, the foot was dorsiflexed and the neck flexed and the result of this was also recorded. Straight-leg raising was then carried out on the other side (well-leg

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raising test). Straight-leg raising greater than 70 degrees was considered arbitrarily to be normal, and any limiting pain occurring above this angle was not included in the results but was ascribed to hamstring pain.

Hamstring pain was defined as a tightness or discomfort localised to the hamstring region on straight-leg raising. It was not aggravated by flexion of the neck or dorsiflexion of the foot.

Myelography was performed in forty-three patients, the operator in each case having no knowledge of the clinical findings. An average of 6 millilitres of Myodil was introduced into the lumbar theca and films were taken in prone, erect, flexion and extension positions to determine the degree of dural or root sleeve deformity. In a few cases in which root sleeve filling was inadequate on the first occasion, the patient was re-examined on the next day.

Each myelograph was classified as follows. In Group 1, there is dural deformity in both the antero-posterior and lateral projections (Fig. 1). In the antero-posterior projection there is a characteristic "hour-glass" constriction of the dura indicative of central disc protrusion. In Group 2 there is unilateral dural deformity with, in addition, defective or absent root sleeve filling (Fig. 2). Lateral films taken in flexion and extension show persistence of the dural defect in both positions (Fig. 3). In Group 3, or lateral type, there is absent or defective root sleeve filling without any evidence of indentation of the dura in the oblique, postero-anterior or lateral projection (Fig. 4).

In all the patients the presence of a lower lumbar disc protrusion was confirmed at operation. The protrusions were classified into three types according to their position relative to the dura. Group 1 protrusions lie centrally. They are in contact with, and completely overlapped posteriorly by the dura. Except in cases of massive prolapse, Group 1 protrusions have no contact with root sleeves or extradural nerve roots. Group 2 protrusions are
Radiological Group 3. Figure 2—Intermediate type of disc lesion between the fourth and fifth lumbar vertebrae. There is deformity of the root pouch and dural sac on the left. Figure 3—Lateral projections with patient erect show persistence of the dural defect in flexion and extension.

Radiological Group 3. Lateral lumbo-sacral disc prolapse. There is amputation of the fifth lumbar root sleeve on the left, but no deformity of the dural sac is shown in the oblique, postero-anterior or lateral projection.
intermediate in position and impinge upon both dura and nerve roots. Group 3 lesions protrude laterally, deforming the nerve root sheath alone.

This classification was considered to be comparable with the myelographic grouping. In addition to the location of the protrusion at operation, the level, size and type (whether a bulge, herniation or extrusion) were noted in each case.

ILLUSTRATIVE CASES

Case 1—A man aged forty-six gave a ten weeks' history of low back pain with radiation down the postero-lateral aspect of his left leg into the lateral aspect of the left ankle. Before this, he had had intermittent low back pain for two years. Passive straight-leg raising was limited on the left to 40 degrees and caused the left-sided low back pain. The neck flexion test and foot dorsiflexion test both caused an increase of this pain. No pelvic tilt on leg raising was observed. Right straight-leg raising caused pain of similar distribution at 60 degrees, again with positive neck flexion and dorsiflexion tests. There was no neurological abnormality. Myelography showed a Group 1 protrusion at the fourth lumbar level (Fig. 1). At operation the anterior dura was found to be stretched over a sequestrated Group 1 disc protrusion at the fourth lumbar level. This was sited slightly to the left side of the midline. The extruded disc was removed and the disc space evacuated, with relief of symptoms.

Case 2—A man aged thirty-one was admitted to Oswestry with a six weeks' history of lumbo-sacral pain and left sciatica which was localised to the fifth lumbar dermatome. Passive straight-leg raising on the left induced pain down the left leg localised to the fifth lumbar dermatome and was limited to 45 degrees. There was weakness of the long extensor of the toe with some diminution of pin prick over the dorsum of the left foot. Both neck flexion and foot dorsiflexion aggravated this pain. No pelvic tilting was noted. Right straight-leg raising caused hamstring pain only at 70 degrees. Myelography showed absence of the left fifth lumbar dural root sleeve, suggesting a Group 3 protrusion at the fourth to fifth lumbar level (Fig. 4). At operation, the myelographic impression was confirmed by the finding of a lateral Group 3 disc herniation. The fifth lumbar nerve root was stretched tightly over the disc herniation. There was no involvement of the main dural sac. Excision of the disc material produced a good clinical result.

RESULTS

Clinical features—Fifty patients (thirty men and twenty women) were investigated. The mean age was thirty-eight. The length of each recent bout of pain varied between six weeks and eight months. Straight-leg raising on the affected side ranged from 10 to 60 degrees. Straight-leg raising on the other side ranged from 30 to 70 degrees. The pattern of pain induced by passive straight-leg raising fell into three well-defined groups. Ten patients experienced low back pain, seventeen experienced leg pain and twenty-three had a combination of low back and leg pain. Neck flexion and foot dorsiflexion was performed in forty-five patients. On straight-leg raising on the affected side, thirty-five had a positive neck flexion, and forty-one a positive foot dorsiflexion test. The results of the neck flexion and foot dorsiflexion tests

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TABLE I

RESULTS OF NECK FLEXION AND FOOT DORSIFLEXION TESTS RELATED TO SITES OF PAIN AND POSITION OF PROTRUSION

<table>
<thead>
<tr>
<th>Position of protrusion as found at operation</th>
<th>Number of cases</th>
<th>Neck flexion test</th>
<th>Foot dorsiflexion test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cases with positive finding</td>
<td>Site of pain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Back</td>
<td>Leg</td>
</tr>
<tr>
<td>Central</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Intermediate</td>
<td>24</td>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>Lateral</td>
<td>14</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>45</td>
<td>35</td>
<td>19</td>
</tr>
</tbody>
</table>

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in relation to patterns of induced pain and the correlation with the position of the protrusion at operation are shown in Table I. The well-leg raising test caused pain in twenty-two of the fifty patients (44 per cent). Pelvic rotation occurred in about a third of the cases, and was observed to commence between 30 and 60 degrees. It was marked in only one patient. Hamstring pain occurred in five patients, in each case in the limb other than that affected. This finding was not included in the results on leg pain.

Radiological observations—Myelography was performed on forty-three patients. A double lesion was present in one instance, so that forty-four disc lesions were available for analysis.

The myelographic placement of the disc protrusion relative to the dural sac was as follows: central (Group 1) thirteen cases, intermediate (Group 2) nineteen cases, lateral (Group 3) nine cases.

**TABLE II**

<table>
<thead>
<tr>
<th>Position of protrusion</th>
<th>Number of cases</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L3-4</td>
</tr>
<tr>
<td>Central</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>27</td>
<td>—</td>
</tr>
<tr>
<td>Lateral</td>
<td>16</td>
<td>—</td>
</tr>
</tbody>
</table>

**TABLE III**

Relation of Position of Protrusion as Found at Operation to the Pattern of Pain Produced by Straight-Leg Raising

Fifty cases of lower lumbar disc prolapse

<table>
<thead>
<tr>
<th>Position of lesion</th>
<th>Number of cases</th>
<th>Distribution of pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low back</td>
</tr>
<tr>
<td>Central</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Intermediate</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>Lateral</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

There were three false negative myelographs. In these, even after re-examination of the myelographs, no definite abnormality could be identified. They occurred in patients with lateral disc prolapses. In two of them it was noted that there was extradural extravasation of Myodil at the time of introduction.

One patient had a false positive result. In this instance a definite lateral disc protrusion was demonstrated at the lumbo-sacral level and was subsequently confirmed. A small central protrusion was suspected at the L.4-5 level, but at operation there was no evidence of a lesion at this level.

Findings at operation (Table II)—There were eight central, twenty-seven intermediate and sixteen lateral disc protrusions. Different types of disc pathology were recorded. There were thirty herniations and fourteen extrusions, and in three cases there was only the scarred remnant of a disc. In four patients there was a pronounced central disc bulge. One patient had protrusions at two levels.
Correlation of clinical and myelographic findings—A study of the correlation between clinical and operative findings shows that the straight-leg raising pain pattern bears a definite relationship to the position of the protrusion (Table III). Central protrusions tend to cause pain in the back on straight-leg raising, lateral protrusions cause pain in the leg on straight-leg raising, and intermediate protrusions cause a combination of both. On this basis, the distribution of pain on straight-leg raising allowed accurate prediction of the location of the dural lesion in forty-one out of fifty-one cases—80 per cent. The pattern of pain induced by raising the leg opposite to that affected is also consistent with the findings on raising the affected leg (Table IV).

In ten patients the distribution of pain on straight-leg raising did not correspond with the position of the protrusion. Four patients with Group 2 protrusions experienced leg pain alone on straight-leg raising. In three of these, there was marked lateral fibrosis and nerve root adhesion. The findings on straight-leg raising simulated those associated with lateral protrusion. Two Group 2 protrusions gave rise predominantly to pain in the buttock, which was incorrectly classified with low back pain. Pain in the buttock appears to be difficult to interpret. Another patient was found to have a protrusion at two levels and the pain on straight-leg raising corresponded only with one of these. Thus, a patient with a lateral disc protrusion experienced low back pain on straight-leg raising. In only one patient was there difficulty in assessing the pattern of pain on straight-leg raising. In this case, tightness of the hamstrings and straight-leg raising beyond 20 degrees caused marked spasm with pelvic rotation giving rise to movement of the lumbar spine. The patient complained of back pain on straight-leg raising and was found at operation to have a lateral disc protrusion.

The myelographic correlation is shown in Table V. There was accurate correlation of the myelograph with the findings at operation in thirty-five out of forty-four patients. In the remaining nine, the myelographic deformity appeared larger than the appearance of the

<table>
<thead>
<tr>
<th>Table IV</th>
<th>Incidence of limitation of well-leg raising and pain pattern related to the position of the disc protrusion found at operation in fifty cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site of protrusion</td>
<td>Number of cases</td>
</tr>
<tr>
<td>Central</td>
<td>8</td>
</tr>
<tr>
<td>Intermediate</td>
<td>27</td>
</tr>
<tr>
<td>Lateral</td>
<td>16</td>
</tr>
</tbody>
</table>

* A double lesion was found in one patient.

<table>
<thead>
<tr>
<th>Table V</th>
<th>Relation of clinical and myelographic findings to the location of the protrusion as found at operation in fifty cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Position of protrusion</td>
<td>Number of cases*</td>
</tr>
<tr>
<td>Central</td>
<td>8</td>
</tr>
<tr>
<td>Intermediate</td>
<td>27</td>
</tr>
<tr>
<td>Lateral</td>
<td>16</td>
</tr>
<tr>
<td>Overall correct prediction</td>
<td>41/51 (80 per cent)</td>
</tr>
</tbody>
</table>

41/51 (80 per cent) 35/44 (79 per cent)
disc protrusion at operation; these patients were placed in the next group. Five patients with intermediate (Type 2) disc protrusions shown at operation, had myelographic deformity suggesting a central (Group 1) type of lesion. In one other patient, in whom a lateral disc protrusion was found at operation, dural deformity associated with root sleeve amputation was shown on the myelograph: this was classified as an intermediate type of lesion.

In one further patient with lateral lumbo-sacral disc protrusion shown at operation, myelography suggested in addition a small central disc prolapse between the fourth and fifth vertebrae. This was not confirmed at operation.

The clinical and myelographic findings are compared in Table V. The straight-leg raising test correctly predicted fourteen out of sixteen lateral lesions and this test was more accurate than myelography. Myelography, however, was slightly more accurate in predicting central lesions.

The level of the disc protrusion could be predicted clinically in only twenty-five out of the fifty patients. With myelography, the correct level was predicted in forty-one out of forty-four cases. There appeared to be no correlation between the pattern of pain induced by straight-leg raising and the degree of disc protrusion present.

**DISCUSSION**

Within the limits of this small series, it seems that the pattern of pain on straight-leg raising bears a close relationship to the central or lateral position of the disc protrusion. The straight-leg raising test may, in addition to its use in diagnosis and in assessment of progress, be helpful in localising the protrusion by analysis of the distribution of the pain so induced.

The position of the disc protrusion may be considered by reference to two co-ordinates. In the horizontal axis, protrusion may occur in a central, intermediate or lateral position (Groups 1, 2 and 3). The vertical co-ordinate places the level of the protrusion. By analysis of the pattern of pain induced by straight-leg raising it was possible to predict the horizontal location of the disc in 80 per cent of cases. The prediction of the level of the protrusion was accurate in only 50 per cent of cases. This compares with Lansche and Ford's (1960) clinical diagnostic accuracy of 39·2 per cent obtained without use of the test of production of pain by straight-leg raising.

**TABLE VI**

<table>
<thead>
<tr>
<th>Myelographic location</th>
<th>Number of cases</th>
<th>Pattern of pain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low back</td>
</tr>
<tr>
<td>Central</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Intermediate</td>
<td>19</td>
<td>—</td>
</tr>
<tr>
<td>Lateral</td>
<td>9</td>
<td>—</td>
</tr>
<tr>
<td>False negative</td>
<td>3</td>
<td>—</td>
</tr>
</tbody>
</table>

Myelography accurately demonstrated the level of disc protrusion in forty-one out of forty-four patients with lesions confirmed at operation. In one case, two disc lesions at adjacent levels were shown when only one lesion was suspected clinically.

We feel that this study underlines the complementary roles of myelography and clinical assessment in the diagnosis of lower lumbar disc disease. Myelography is most valuable for identifying the level of the disc lesion and for excluding multiple lesions and other pathological processes. The straight-leg raising pain test is valuable in locating the horizontal position...
of the disc. This may be of particular help when a very lateral disc lesion is clinically suspected—a lesion that may not be detected on myelography with oil-based contrast media.

The overall accuracy of this myelographic study is comparable with the findings of other workers (Leader and Rassell 1953). In this study three lateral disc lesions were not diagnosed by myelography, but in two of these there was extradural extravasation. Wright, Saunders, Steel and O’Connor (1971) in a review of 138 myelographs in cases of intervertebral disc lesions reported thirteen instances of failure to demonstrate lateral protrusion. It is possible that the use of water-soluble contrast media may improve diagnostic accuracy.

![Fig. 5](image1)
![Fig. 6](image2)

**FIG. 5**
Effect of passive straight-leg raising on the dural sac. Intermediate type of disc prolapse between fourth and fifth vertebrae. Figure 5—Patient supine in relaxed position. Figure 6—Passive right straight-leg raising produces elongation of the fifth lumbar root pouch and a “bowstring” effect of the dura over the prolapsed disc. This is caused by deviation of the lower dural sac to the side of the prolapsed disc.

It may be difficult to estimate the size of a disc lesion accurately from the size of the defect in the column of contrast. In six patients the size was over-estimated. Five intermediate disc prolapses (type 2) were recorded as central and one lateral lesion as intermediate. Dural deformity shown by myelography depends not only on the size and position of the protrusion but also on the shape of the bony canal and the width of the extradural fat pad. It is possible that in these instances there was some reduction in size of the lateral recess, or reduction in configuration of the canal, which appeared to augment the defect shown by myelography. Here again, the straight-leg raising test may assist in the accurate location of the disc lesion (Table VI).

Several hypotheses have been advanced to account for the pain in the back and leg on straight-leg raising. In his original thesis Forst suggested that pain in the leg was caused by compression of a sensitive sciatic nerve by tight hamstrings (Rang 1966). O’Connell (1943) suggested that leg pain arose from direct irritation of the nerve root by movement or tension
over the protrusion. The experimental work of Smyth and Wright (1958) who used nylon loops to stimulate nerve roots in laminectomy patients led them to similar conclusions. Breig and Marions (1963) suggested that the concept of compression of nerve roots by a herniated lumbar disc was inappropriate and suggested that increase in root tension, from neck flexion in particular, might cause deformation of lumbar nerve roots by a herniated disc. In the present study the production of leg pain by straight-leg raising in cases of lateral disc prolapse further supports the root irritation theory.

Pain in the back caused by straight-leg raising is more difficult to interpret. O'Connell (1943) concluded that it was related to lumbar spinal movement. However, in all but one case in the present series, pelvic rotation causing lumbar spinal movement appeared to be minimal. In addition, the neck flexion test and foot dorsiflexion test were positive in nearly all cases.

Falconer, McGeorge and Begg (1948) noticed when operating under local analgesia that pressure on the protrusion with a probe caused back pain. This leads to the suggestion that pain in the back caused by straight-leg raising may be due to increased tension on structures overlying the disc, especially when it is under pressure. Spurling (1953) considered that this pain might arise from movement of the sacro-iliac joint. Steindler (1947) considered that back pain in cases of nerve root irritation might be due to reference of pain along the posterior primary ramus. In the present study, the close association between the pain and Group 1 protrusions impinging on the anterior dura suggest that dural irritation could well be the cause. Certainly, the anterior dura and epidural tissues are innervated (Jackson, Winkelsmann and Bickel 1966; Edgar and Nundy 1966). This theory is further supported by the findings that neck flexion, which produces tension in the dura as well as in the nerve roots (Breig and Marions 1963) promptly caused aggravation of back pain (Table I).

We were able to study the effect of straight-leg raising on the myelographic appearances of the root pouches in only a few patients. Figures 5 and 6 show the effect in a patient with an intermediate disc protrusion, in whom passive straight-leg raising produced pain in the back and leg.

**SUMMARY**

1. Passive straight-leg raising may induce pain in the back or leg or a combination of both in patients with acute lower lumbar disc lesions. Clinical, myelographic and operative observations were carried out prospectively in fifty such cases to investigate the relation of the pattern of pain on straight-leg raising to the site of the protrusion.
2. In patients with central protrusion straight-leg raising induced mainly back pain. In patients with intermediate protrusion, lying in contact with both dura and nerve root, a combination of back and leg pain predominated. Patients with lateral protrusion usually experienced only pain in the leg. This correlation was found in 80 per cent of cases.
3. Production of pain in the leg by straight-leg raising is of practical significance in lateral protrusions where myelography may be normal.
4. Pain in the back and pain in the leg on straight-leg raising may be related respectively to dural and nerve root sensitivity.

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**REFERENCES**


