NERVE-ROOT ANOMALIES IN LUMBAR-DISC SURGERY

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The finding of anomalies of nerve roots during operations on lumbar discs either has escaped the surgeon’s observations or has been considered relatively unimportant. We report our observations describing three varieties: the conjoined roots, the transverse root, and the anastomotic roots.

The analysis of our cases and the few reported in the literature suggests that the procedure of removal of lumbar discs and/or decompression of anomalous nerve roots has been somewhat unrewarding. Furthermore, we have been under the impression that some of these anomalies may cause pain without the presence of a herniated disc.

We hope to stimulate others to be alert for these anatomical variants and to report their findings in order to further elucidate this problem.

CASE REPORTS


O.T.S., a 46-year-old farmer, 10 weeks prior to examination, during heavy lifting, started to have low-back pain. It was severe enough to keep him away from work, and he had been almost nonambulatory since onset. The pain was localized and without radiation, disappeared when lying down, but was present or worse with movement or strain.

Examination. Neurological findings were normal, including Lasègue’s sign bilaterally, but there was loss of lumbar lordosis with marked spasm of muscles. Cerebrospinal fluid contained 30 mg. of protein. Myelography revealed indentation at the 5th lumbar interspace.

Operation. Partial hemilaminectomy at L4 and L5 was performed. No protrusion of disc was found at L5 level, but the L5 root was found emerging at a right angle from the dural sac, and passing directly to its intervertebral foramen after a brief transverse course (Fig. 2a). No abnormality of disc was found at this level. Exploration at L4 did not reveal evident protrusion of the disc, but it was found to be quite soft. It was opened and a piecemeal removal was carried out.

Evolution. Four months after surgery, patient remained symptomless.

Case 2. Usual history of disc and neurological findings. Herniated disc overridden by conjoined L5 and S1 roots. Minor relief.

C.V., a 30-year-old Negro truck driver, was examined 2 months after injury of his back. He suffered pain which initially radiated along the left leg, but later spread into the right gluteus, thigh, and to the knee. There was severe tingling in the right leg. The pain was worse when arising from sitting or lying on his back.

Examination. There was a positive Lasègue’s sign bilaterally. Reflexes were equal, but slight weakness of the extensor hallucis longus, as well as slight sensory impairment, probably in the L4 distribution, were found.

Operation. Exploration with patient in lateral position was carried out. Partial hemilaminectomy at L4 permitted satisfactory observation of normal-looking disc and L4 root. Partial laminectomy of the lower rim of L5 lamina exposed the L5 and S1 roots, conjoined in a common trunk, not longer than 1 cm. The L5 root went out from the dura mater in a perpendicular course whereas the S1 coursed obliquely downward to normal exit from spine (Fig. 2b). A bulging paracentral lumbo-sacral disc was found and removed.

Evolution. The patient kept complaining of variable pain in his back and his leg, particularly on arising from sitting position. On wearing a brace, some improvement was obtained. Disability was still present 6 months after operation.

Case 3. Three unsuccessful explorations for low-back and leg pain. Last one showed conjoined L5 and S1 roots and no herniation of disc.

F.R.M., a 60-year-old housewife, about 2½
years prior to examination, suffered severe low lumbar pain which was aggravated by motion. Myelography at that time revealed slight deviation of the contrast medium at L5 interspace. Following this procedure, pain became worse and radiated to buttocks. She was operated upon elsewhere; bilateral exploration of L4 and L5 interspaces was carried out through L5 laminectomy. Following operation, the patient continued to suffer from numbness and pain in her right back, hip, and all of leg. This persisted to point that 1 year later the area was explored again elsewhere; no abnormality was found. The pain was unmodified. When admitted to hospital, the patient complained of dull, boring pain in the lumbar area, and numbness, or "wooden" feeling of the right leg and ankle. Pain was worse on movements or strain at which time it radiated along the thigh to her toes.

Examination. Abnormal neurological findings were moderate spinal spasm, some weakness of the extensor hallucis longus, depressed left Achilles reflex, and sensory changes within the distribution of L5 and S1 roots. Laségue's sign was negative. Myelography revealed the same changes as were found the first time. In view of the uncontrollable pain, operation was advised.

Operation. With the patient lying on her side, the previous scar was excised, and the roots were clearly identified. The S1 and L5 roots on the left side were found arising from a common trunk. The L5 root ran a course perpendicular to the dura mater, and S1 ran obliquely downward (Fig. 1). Careful dissection of roots from scar tissue was carried out. No further herniation of disc was demonstrated.

Evolution. The patient has shown practically no change since operation. She complains of pain in the leg as well as pain in her back.

Case 4. Chronic low-back and gluteal pain. Midline herniation of L4 disc and conjoined L5 and S1 roots at one level below. Poor results.

B.C.R., a 55-year-old white housewife, complained of lumbosacral and right gluteal pain for approximately 4 years. It was worse under movements or strain, and often radiated as a sharp or dull ache into the right groin. There was complaint of pain in the vagina.

Examination. There was marked spasm of the spinal muscles and Laségue's sign was present. The right leg was thinner than the left, particularly at the calf. The patient was of neurasthenic type. Myelography carried out 1 year previously had shown persistent defect at L4 right. Repeated myelography previous to operation corroborated the findings.

Operation. Exploration was made with patient in lateral position. Subtotal hemilaminectomy of L4 and total of L5 had to be carried out. The L4 root was found lying over a mid-line protrusion of disc, which was removed. The S1 nerve root was fused with L5 to form a larger common trunk, less than 1 cm. long, originating from the lumbar area down (Fig. 2d). It was impossible to retract these roots medially or downward. Exploration of the lumbosacral disc was carried out with great difficulty through an anomalous axilla of S1 root. The disc was hard and somewhat elevated, but not ruptured. Complete hemilaminectomy was carried out to evaluate the anomaly properly and to provide suitable decompression.

Evolution. During 3 months after operation, the patient continued to complain of rectal-vaginal burning pain. There was no catching pain in the back, but there was soreness in the leg. Her emotional unbalance was outstanding.


F.F.C., a 34-year-old housewife, had a 2-year history of low backache until 2 months prior to examination. Heavy lifting then produced low back pain and bilateral sciatica. Backache was noted on turning of head. Pain was aggravated.

FIG. 1. Case 3. Photograph taken at operation. Black threads have been used for demonstration, passing underneath the conjoined root (A), 5th lumbar (B), and 1st sacral (C) divisions.
bilateral and/or sacral dermatomes. The L5 root was opened, and a large conjoined root was observed. The root was then biopsied, and it was reported as not a tumor, but a dorsal root ganglion.

Examination. This patient never felt entirely relieved of pain. She complained of low-back pain aggravated by activity, and improved by wearing a brace or by rest. When last seen \(1 \frac{1}{2}\) years after operation, there was no change.

**GENERAL MORPHOLOGICAL CHARACTERISTICS**

We have illustrated in Fig. 2 the general appearance of the malformations of the lumbar root that have been observed in the course of surgical exploration. Anomalies of the spinal roots have been known by the classic anatomists, and have been said to be symptomless. They are described as occurring with decreasing frequency from the cervical to the lumbar region. Ethelberg and Riishede found 4 cases in 1,612 operations on the lumbar spine; however, we feel they are not so infrequent since as soon as one of us (BWC) called attention to the fact, about 4 years ago, not only were 4 additional cases seen by the authors, but 4 other neurosurgeons of the same locality found similar cases. We believe that the failure to recognize these anomalies more frequently is because of the current vogue of submitting most herniations of the lumbar discs to restricted exploration.

The first fact deserving of attention is that most malformations involve the L5 or S1 roots. This does not imply necessarily any topographical selectivity since these roots are the most frequently explored during operations for herniated disc.

We have distinguished three different morphological types:

1. **Conjoined roots.** In this type, two adjacent root sleeves show a common origin as they arise from the dura mater (Fig. 3). After a short or long joined course, they may separate to make their exit from the spine through independent foramina, or they may remain joined and together leave the spine through the same intervertebral foramina. To our knowledge, similar observation
has been made by Dr. Francis Murphey, Dr. E. C. Schultz, and Dr. Richard L. DeSaussure, Jr.

2. Anastomosis between roots. Usually a branch is given off by the root shortly after emitting from the dura mater and joins the immediately lower root obliquely. Dr. Bernard S. Patrick likewise has observed anastomosis between the L4 and L5 roots in a patient operated upon for ruptured disc.

3. Transverse course of the root. This anomalous root usually originates at a lower level than the average, and constructs approximately a right angle with the dura mater. The root follows a transverse course to the exit of the intervertebral foramen.

In our opinion, it should not be taken for granted that these abnormal root sleeves contain only normal roots, because these sleeves rarely have been opened at operation. In 1 of the cases explored by Ethelberg and Riishede, the dura mater was opened and the roots were bound in a common arachnoidal sleeve that could be followed even among the roots of the cauda equina. In the only case in our series in which the sleeve was opened, the biopsy revealed that the root ganglion was located abnormally in the conjoined sleeve (Case 5).

The same uncertainty is present in regard to the possibility of these anomalies being bilateral. In the few patients that have been explored bilaterally, the anomaly was found on only one side.

It would seem reasonable that most of these abnormalities of roots can be explained as defects in the migration of the roots during their embryological development. They could occur either as the result of a local factor, as suggested by the isolated anomaly, or the consequence of a widespread embryological disorder as suggested by our Case 5, in which other anomalies, sacrum bifidum and situs inversus of the viscera, were found.

GENERAL CLINICAL CHARACTERISTICS

In this brief series of surgically proven cases, both sexes seem to be affected with the same frequency. The malformations were discovered between the third and sixth decade of life; however, 3 patients had experienced symptoms from 7 to 13 years previously. The symptoms in these cases may or may not be related to the malformation itself (Table 1).

In the surgical explorations carried out, the surgeon was unable to find discal protrusion of any apparent significance in 5 instances. This small group of patients probably represents better the clinical symptomatology that may be related singularly to the malformation. Lumbago has been the dominant feature, either of acute excruciating onset, or of chronic recurrent type. A frequent characteristic is the onset of pain after heavy lifting or a strain, as well as increase of pain by movement, and relief by rest. Pain may radiate to the hip and buttocks or along the sciatic distribution to the ankle. Numbness was reported in 1, and tingling dysesthesia was reported in 2. The most prominent feature would be the absence of Lasègue’s sign. With the possible exception of Ethelberg and Riishede’s Case 1, of questionable validity, in all the cases reviewed or observed that did not reveal herniation of disc, the Lasègue’s sign was negative. This negative fact is the only clinical difference that we have noticed from the usual syndrome of protruded disc. Restriction of spinal motility to various degrees, hyperesthesia in the distribution of the root, weakness in dorsiflexion of foot or extensor hallucis longus, etc., have all been noted. The cerebrospinal fluid, when obtained, has been normal.

Fig. 3. Artist’s reconstruction of the “conjoined nerve roots” anomaly. Note necessity of retracting the dura mater to expose the malformation properly.
TABLE 1

Reported surgical cases of lumbar spinal root anomalies*

<table>
<thead>
<tr>
<th>Case</th>
<th>Age and Sex</th>
<th>Duration</th>
<th>Clinical Features</th>
<th>Operations</th>
<th>Findings</th>
<th>Results Last Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>55 yrs. F</td>
<td>4 yrs.</td>
<td>Recurrent pain lumbar region, buttock, and groin on rt. Worse on strain</td>
<td>Removal disc; decompression</td>
<td>L4 disc. Conjoined L5/S1</td>
<td>Little improvement. 3 mos.</td>
</tr>
<tr>
<td>8</td>
<td>37 yrs. F</td>
<td>7 yrs.</td>
<td>Lumbago and tingling rt. foot</td>
<td>Lasègue negative. Restricted spine, hypesthesia leg</td>
<td>1) Decompression 2) Exploration</td>
<td>1) Disc L3 2) Conjoined L5/S1 passing through L5</td>
</tr>
<tr>
<td>9</td>
<td>49 yrs. M</td>
<td>12 yrs.</td>
<td>Recurrent strain. Lumbago and rt. sciatica</td>
<td>Decompression</td>
<td>No disc</td>
<td>No pain, weakness. 10 mos.</td>
</tr>
</tbody>
</table>

*Cases 1 to 5 are reported herewith.
Cases 6 to 9 were reported by Eiberg and Riisbøe.2

The simple roentgenograms are similar in every aspect to those in cases of the usual herniated disc, or are normal. No changes in size or shape of the intervertebral foramen were found in our cases. Indirect assumption of the possibility of multiple malformations, including roots, can be established if some other abnormalities also are found. Myelograms frequently show abnormalities such as sleeve defect and slight deviation of the column of oil; findings that are indistinguishable from those of the usual discal protrusion.

Clinically, thus far, these cases have never been predicted before operation. We believe that when Lasègue’s sign is present, these cases cannot be suspected and probably will continue to be observed as operative findings in cases diagnosed as herniated disc. However, a negative Lasègue’s sign within the general picture of a herniated disc should place the case among the “atypical disc syndromes,” and root malformations, as well as other spinal conditions, should be considered.

SURGICAL OBSERVATIONS

Without exception, in all cases that we have reviewed the preoperative diagnosis was protruded disc. Of the 9 tabulated cases, there were 3 in which the patients were subjected to more than one surgical procedure before the malformation was discovered. The operation usually consisted of removal of the disc when some abnormality
was suspected, and/or decompression of the root by removing part of, the whole lamina, or the facet.

Direct dealing with these abnormalities in surgical explorations allows some observations and comments.

The pedicle, and/or the facet, may be factors in the pathogenesis of neuropathy in the conjoined root. This fact can be noted by observing the topographical relationship of the take-off by the conjoined root from the dura mater. The branches of the conjoined root are so fixed by this common origin that more than the usual irritation may result as they are snubbed around the pedicle. Any acute tension placed on the abnormally fixed root could produce a significant neuropathy. This part that the pedicle plays may account for the poor results obtained after a ruptured disc is excised from beneath the conjoined root.

The significant factor may be the excessive surgical trauma that can result from attempts to extract or excise a ruptured disc from beneath the unusually fixed conjoined root. Our attention to the fact that such a malformation occurs was brought about by unusual difficulty encountered in mobilizing the conjoined root from over the dome of an obviously ruptured disc. Full hemilaminectomy to visualize the problem better revealed the anatomical oddity.

We also believe that the lateral position in operations for protruded discs has played a part in our encountering a significant number of conjoined roots. With the patient flexed laterally and ventrally,* a larger area of the nerve root, disc, and foramen is exposed to vision. This enabled us to encounter directly the peripheral division of the conjoined root. There may be a frequent error in observation that has obscured this entity. The common trunk can appear to be an enlarged edematous root or ganglion and not attract unusual attention because of its size.

By the same token, an enlarged root frequently is less mobile than a smaller flattened root, and may fail to raise suspicion of its anatomical variation as a conjoined root. We have wondered if in many of the cases during which exploration for protruded disc revealed an unusually large root, there actually was not an anatomical variation instead of an edematous root, as assumed frequently.

One significant clue signaling the presence of a conjoined root is the observation of the root arising at a less acute angle from the sagittal axis of the dura mater. This may even construct a 90° angle to the dura mater. To note such a variation demands adequate exposure. The tendency to perform operations for herniated discs via a minimal exposure precludes the probability of noticing this feature. Any root that poses unusual difficulty in mobility when approaching a ruptured disc deserves additional exposure for evaluation of its anatomy.

To date, we have not synthesized an adequate procedure for solving this problem. Recognition of its presence is thus a paramount factor. This would lead to a more adequate exposure of the surgical environ, and consequently, less trauma to the root during removal of the ruptured disc. A more radical excision of the dorsal bony elements, particularly the pedicle, may be necessary. Fusion may be considered, particularly if the conjoined variation proves to be bilateral. Because of the fact that anatomical sources do not help in determining the incidence of bilaterality, we do believe that, in all such cases encountered in the future, the opposite side should be explored. Many questions stand out immediately, but the answers will have to wait until additional experience is accumulated. The almost universally poor results in the management of these patients prompted this warning communication.

SUMMARY AND CONCLUSIONS

During operations for protruded discs we have observed and recorded abnormalities of the nerve roots in 5 cases. In the report of

* The lateral position for surgery of lumbar discs has been illustrated in a motion picture by Dr. B. W. Cannon at the Second International Congress of Neurological Surgery, Washington, D. C., Oct. 18, 1961.
these cases, we mentioned the "conjoined root," the transverse, and the anastomotic varieties.

Our observations lead us to believe that these malformations should be noted more frequently. The need for additional cases is evident before appraisal of anatomoclinical data can be ascertained. However, study of this small series suggests that a negative Lasègue's sign, in the presence of an otherwise typical syndrome of lumbar disc, may prompt one to suspect an abnormality. Myelograms in these cases have not been helpful, and even misleading. The absence of definite protrusion or rupture of the disc in some of our cases suggests that a different mechanism for the pain in these cases of abnormalities may be discovered. Our surgical management of these cases of abnormalities of nerve roots, with or without frank protrusion of disc, has not been satisfactory.

We hope other neurosurgeons will report their observations, as we are under the impression that these anomalies may bring about pain without the presence of herniated disc.

ADDENDUM

Since this paper was submitted for publication, 3 additional cases have come to our observation. The first showed fusion of the L5 root with the lumbar dural sac for about 1.5 cm. before separating and taking off toward its normal exist. The second revealed the L5 root with two portions arising and traveling together until their L5 foramen. One portion was rather large in size and the other was a small rootlet entirely under cover by the larger root. The third showed L5 and S1 roots arising one immediately below the other and traveling parallel and so close together that a double-size lumbar root was assumed until proper exposure revealed that close to their foramina both roots separated, each one going to its proper exit from the spine.

REFERENCES
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3. Murphy, F. Personal communication.
4. Patrick, B. S. Personal communication.
5. Schultz, E. C. Personal communication.