INTERVERTEBRAL FORAMEN STUDIES

I. FORAMEN ENCROACHMENT ASSOCIATED WITH DISC HERNIATION*

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These studies are the outgrowth of observations coordinating the radiographic and morphologic studies of cadaver spines. The specimens were supplied by the Anatomy Department at Syracuse University Medical College. Following radiographic examination the nerve roots were removed, embedded in paraffin and the section stained with hematoxylin eosin.

An examination of the normal lumbar foramen section (Fig. 1) shows the nerve root (N) or its ganglion occupying only about 1/6 to 1/4 of the opening. Surrounding the nerve is a generous reserve cushion space containing blood vessels, lymphatics,

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fat and areolar tissue. These compressible structures constitute a safety factor during the normal foramen constriction incidental to spinal movement. In each of the four sections here shown the disc (D) is on the left side. The ligamentum flavum (F) is somewhat hypertrophied in one of these sections.

Permanent constriction of the foramen, from any cause, reduces the reserve cushion space. This predisposes to root pressure in the event of edema, hemorrhage, perineural inflammation or additional foramen encroachment.

The most common cause of foramen constriction is disc degeneration and its secondary changes. These include: herniation of disc substance into the foramen, thinning of the disc with approximation of the pedicles, subluxation of the upper vertebra forward or backward upon the one beneath, hyperplasia of the ligamentum flavum, bony spur formation projecting backward from the disc or forward from the posterior joint, and lastly, subluxation of the articular process from below upward and forward into the foramen. Some of these are illustrated in Fig. 2. A and B are blocks taken from constricted 5th lumbar foramina. In both, the disc is thinned and herniates backward (2) into the foramen. In these the distorted nerve (1) has been outlined. The superior articular process (3) from the sacrum has subluxated upward and forward into the foramen, constricting that opening. This has impinged against the under surface of the 5th pedicle at (4). Fig. 2C is the section (×1.7) from an encroached 5th lumbar foramen. The triangular-shaped nerve root (1) has become compressed between the pedicle above and the disc substance (2) herniating backward into the foramen.

Fig. 3 is the right lumbosacral spine of a male 83 years old. He had complained of low back pain for many years but no history of sciatica was obtained. A shows herniation of the 4th lumbar disc backward into the spinal canal (arrow) displacing the distal nerve roots. The
Fig. 3.

Postmortem myelograph corroborated this disc protrusion and showed displacement of the distal roots. The lateral radiograph (B) indicates encroachment of the 4th intervertebral foramen (arrow). On the lateral photograph (C) the numerals indicate the posterior portion of each intervertebral disc. This man had a subluxation of the 4th and 5th posterior articulations with encroachment of the 4th foramen. Impingement of the 4th superior articulating process against the under surface of the 3rd pedicle is indicated by the long arrow. The articulations and foramina above this point were normal. At the 5th posterior joint there is impingement of the sacral articulating process.

Fig. 4.
against the under surface of the 5th pedicle. A separate intra-articular ossicle, indicated by the arrowhead, has developed at this point.

Nerve roots 2, 3 and 5 appear normal and are surrounded within the foramen by a generous cushion space. Nerve root 4, however, is compressed and flattened by a decrease in the size of the foramen incidental to the posterior joint subluxation as well as a posterior herniation of the disc seen just above and behind the numeral 4.

A somewhat similar case was that of a male aged 62 who had complained of pain in the legs for 8 years before death. The sagittal section of the left side (Fig. 4A) shows a bulging backward of the 4th disc (arrow). The 5th lumbar nerve root was compressed against the posterior wall of the spinal canal at this point. The lateral radiograph (B) shows a spondylolisthesis of L4 forward on L5 but with no break in the neural arch. Marked constriction of the 4th foramen has occurred (arrow).

The ganglion was compressed by the encroached 4th foramen. Many of the large ganglion cells were flattened. Fig. 4C shows the ribbon-shaped 4th spinal nerve (×9) just distal to the ganglion. Marked flattening of the nerve and its constituent bundles has resulted from the herniation of disc substance into the foramen.

Fig. 4D is a section (×325) of the 5th lumbar root. This reveals evidence of nerve degeneration one space below the disc herniation. This high power section, distal to the ganglion, shows normal nerve fibers on the right side and in the lower left corner. Elsewhere there were patches of degenerative change, vacuolation and multiple nuclei in the same tubule. The 5th foramen was not encroached as seen in 4B. The herniated disc at L4 pressed against the 5th root. The patchy degenerative changes distal to the 5th ganglion here visualized may have resulted from that pressure.

These two cases illustrate how disc herniation within the canal may exert pressure upon a lower nerve root while contributing to encroachment of the adjacent foramen. The myelograph in each case would have shown a filling defect. In each the 4th foramen was encroached. Operative removal from the spinal canal of the 4th disc herniation, to relieve the 5th root pressure, would not have cured the foramen encroachment. Successful operative treatment would have necessitated, not only removal of the hernia for distal root pressure, but also proper attention to the adjacent foramen constriction.

Fig. 5 right side, same cadaver as Fig. 4, shows subluxation of the 4th posterior articulation with impingement of the articular process (arrow). The 4th foramen is constricted, while the 3rd and 5th foramina are normal and show ample reserve safety cushion spaces about the corresponding nerve roots. This photograph gives some indication of the difficult problem to be encountered in decompressing such a foramen by facetectomy.
Magnuson,\textsuperscript{4} in discussing "the subject of the low back pain accompanied by so-called sciatica," states that the "approach has been mainly from the standpoint of root pressure from a ruptured intervertebral disc." He adds "this viewpoint seems much too narrow. It is quite apparent that variations in the path of the nerves are frequent not only in the foramen but at the exit from the foramen."

The importance of intervertebral foramen encroachment at once becomes apparent in properly evaluating nerve root pressure. At any operation to relieve intraspinal nerve root pressure, a very careful search within the intervertebral foramen even to its most lateral limits is always indicated. The surgeon must assure himself that no foramen encroachment exists.

The root compression may occur well lateral (Fig. 3C). The foramen is covered by elements of both articular processes. Various writers\textsuperscript{1,2,5,6} have therefore recommended a complete facetectomy (removal of the entire posterior articulation) for decompression of the encroached intervertebral foramen, if that condition is present.

REFERENCES