The anatomy of the so-called “articular nerves” and their relationship to facet denervation in the treatment of low-back pain

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Dissections of the dorsal rami of L1-5 were performed in human cadavers, and the course of the dorsal rami, their branches, and the innervation of the zygapophyseal joints in the lumbar region were specifically studied. At the L-1 through L-4 levels, the dorsal rami divide into medial and lateral branches within the intertransverse ligaments. Each medial branch runs across the root of the adjacent superior articular process. At the caudal edge of the process, the branch turns medially beneath the mammillo-accessory ligament. Beneath the mammillo-accessory ligament, medial branches occur that innervate the adjacent zygapophyseal joint, and distal zygapophyseal branches arise at the laminar level to innervate the next lower joint. The L-5 dorsal ramus runs along a groove between the ala of the sacrum and its superior articular process. At the caudal edge of the articular process, the ramus divides into medial and lateral branches, and the medial branch supplies the L5-S1 articulation.

KEY WORDS • facet denervation • low-back pain • zygapophyseal joint

Facet denervation, facet rhizotomy, and facet rhizolysis is a procedure currently being used in some centers for the treatment of low-back pain syndromes. “Encouraging” success has been claimed for it. The rationale for the operation is that the “facet” joints in the back are the source of pain; the operation is designed to denervate these joints.

The literature describing the operation, however, contains several anatomical inaccuracies in descriptions of the techniques. The facet joints are unlikely to be specifically denervated by the procedure. Rather, the nerve that is most likely to be injured is the medial branch of the posterior primary (dorsal) ramus. The procedure as described is likely to be a medial-branch neurotomy. If the medial branch is the proper target, however, the anatomical localization is inaccurate, and this inaccuracy may be the source of the discrepancies in the reports of success rates of “facet denervation” in clinical practice.

This study was undertaken to provide an accurate description of the lumbar posterior rami, to outline the inaccuracies of “facet denervation” as currently described, and to suggest a reliable method of locating the medial branches of the dorsal (posterior primary) rami. This paper deals only with the surgical anatomy.

Whether or not “facet denervation” or medial-branch neurotomy is a justifiable or effective procedure is another issue.

Materials and Methods

The literature describing the anatomy of the lumbar dorsal rami was reviewed, and for the purposes of this study these nerves were dissected in six embalmed cadavers. On the basis of this anatomy, a method of interrupting the medial branch of the dorsal ramus was devised, based on the percutaneous radiofrequency technique of the type used by Shealy.

Results

Anatomy of Lumbar Vertebrae

The joints of the vertebral arches are formally known as the “zygapophyseal joints.” The usage of this conventional terminology is advocated in place of “facet” joints or other terms. These joints are formed by the superior and inferior articular processes of successive vertebrae. Each superior articular process bears on its dorsolateral surface a prominence of bone: the mammillary process (Fig. 1).
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A prominence of bone arises from the dorsal surface of the transverse process near its junction with the superior articular process. This is the accessory process, and it lies just caudal and lateral to the caudal edge of the superior articular process (Fig. 1). The size of the accessory process varies from a tiny tubercle to a large prominent mass associated with considerable bone overgrowth of the dorsal surface of the root of the transverse process. Large accessory processes are frequent in the L-4 and L-5 vertebrae.

Anatomy of Dorsal Rami

The anatomy of the lumbar dorsal rami differs at the L1-4 and L-5 levels. These are described separately to emphasize the differences.

At the L1-4 levels each dorsal ramus arises from the spinal nerve at about the level of the intervertebral disc (Fig. 2). It passes dorsally and caudally to enter the back through a foramen in the intertransverse ligament. This foramen has been described by Bradley as being bound by "the upper border of a transverse process, the anterior aspect of a superior articular facet, and the bridging inner edge of the intertransverse fascia between these two areas of bone." Lewin, et al., described it as the inferior opening in the dorsal leaf of the intertransverse ligament.

About 5 mm from its origin, the dorsal ramus divides into a medial and a lateral branch. The lateral branches of the dorsal rami pass into the longissimus and iliocostalis muscles, and are of no further interest for present purposes (Fig. 3).

Each medial branch runs caudally and dorsally, lying against bone at the junction of the root of the transverse process with the root of the superior art-

Fig. 1. Osteology of lumbar vertebrae, dorsal view (left), and dorsolateral (right). S = superior articular process; mp = mammillary process; ap = accessory process; L = lamina; SP = spinous process; i = inferior articular process; and TP = transverse process. The arrow indicates the course of the medial branch of the dorsal ramus.

Fig. 2. Dorsal view of the left lumbar zygapophyseal joints (ZJ) and dorsal rami. The erector spinae has been resected to reveal the laminae, joints, and transverse processes. TP = transverse processes of L1-5; lb = lateral branches; mb = medial branches; is = branches to interspinales; I = ilium (resected).
Fro. 3. The proximal part of the course of the L-2 medial branch (mb). The medial branch rises dorsally and caudally across the root of the L-3 superior articular process (sap). mp = mammillary process; tp = transverse process; ap = accessory process; il = intertransversarii laterales; lb = lateral branches. Arrow indicates the target point for medial branch neurotomy. This is the junction of the lateral surface of the superior articular process with the most medial end of the superior border of the transverse process.

Fig. 4. Left: The arrow indicates a proximal zygapophyseal branch of the medial branch of the L-3 dorsal ramus. Right: The arrow indicates one of the distal zygapophyseal branches of the L-3 medial branch. ZJ = zygapophyseal joint; mb = medial branch.
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the fibrous tissue surrounding the joint. It then continues caudomedially across the vertebral lamina (Fig. 3), embedded in the fibrous and adipose tissue that separates the multifidus muscle from the lamina. While crossing the lamina, the medial branch sends a branch to the interspinalis muscle (Fig. 3), and at a variable distance distally the medial branch enters the multifidus through its deep surface. Medial branches also ultimately supply the ligaments and periosteum of the vertebral arches and spines.

Along its course the medial branch supplies two sets of branches to zygapophyseal joints. These articular nerves have no formal name. They are referred to herein as the proximal and distal zygapophyseal nerves, according to their origin from the medial branch.

The proximal zygapophyseal nerves arise from the medial branch as it lies under the mammillo-accessory ligament, or just distal to this point where the medial branch is subjacent to the zygapophyseal joint. They supply the joint from its caudal aspect (Fig. 4 left). The distal zygapophyseal nerves supply the next lower joint. They arise from the medial branch as it crosses the vertebral lamina and course directly caudally to the rostral aspect of the joint (Fig. 4 right). It is apparent that any given zygapophyseal joint receives a dual innervation: the proximal zygapophyseal nerves from the medial branch related to it laterally, and the distal zygapophyseal nerves from the medial branch of the next rostral segment.

It should be noted that the course of the medial branch is fixed at two points: proximally, at its origin from the dorsal ramus in the fibro-osseous foramen at the superior border of the transverse process; and distally, under the mammillo-accessory ligament. The course of the medial branch across the root of the superior articular process is directly between these two points (Figs. 1 and 3). No report of variations in this course are to be found in the available literature. In our cadaver dissections this relationship was found to be constant.

The anatomy of the L-5 dorsal ramus is modified because the transverse process is replaced by the ala of the sacrum. The L-5 dorsal ramus arises from the spinal nerve just outside the L5-S1 intervertebral foramen. It then passes dorsally over the ala of the sacrum, lying against bone in a groove formed by the junction of the ala with the root of the superior articular process of the sacrum (Fig. 5).

Opposite the caudal aspect of the posterior lumbosacral joint, the L-5 dorsal ramus divides into a medial and a lateral branch (Fig. 5). The medial branch hooks medially around the posterior lumbosacral joint, which it supplies, and then ramifies into the multifidus muscle. The lateral branch runs caudally to communicate with the lateral branch of the S-1 dorsal ramus (Fig. 6).

These dissections may be summarized as follows. In the L-1 through L-4 region, each zygapophyseal joint
is innervated by two posterior primary rami. The superior portion of the facet is innervated by distal branches arising from the nerve one level higher. The inferior portion of the facet is innervated by proximal branches arising from the nerve exiting through the neural foramen immediately above the facet in question. At the L5–S1 level, the innervation of the facet is from the medial branch of L-4 and L-5. This means that if any individual facet is to be satisfactorily denervated, it will require either a lesion which is more or less circumferential around the joint, or destruction of the medial branch of the posterior primary rami of two spinal nerves. None of the techniques described in the literature appears likely to completely denervate the lumbar facets, and none is directed at the medial branch of the posterior primary ramus. Since it is unlikely that any of the techniques employed to date will completely denervate a facet, it is not unreasonable to suggest that the apparent beneficial effects of facet denervation relate to a variable injury to the medial branch of the posterior primary ramus rather than to any specific injury to the multiple small branches that innervate the joint.

Reported Techniques of “Facet Denervation”

The literature on “facet denervation” suggests that specific articular branches to the zygapophyseal joints are being destroyed. These branches have been referred to as “the posterior articular nerve of Luschka” or the “articular nerve of Luschka.” In the first instance, this name is a misnomer. The “nerve of Luschka” is an eponymous name for the sinuvertebral nerve which lies in the vertebral canal and which von Luschka first described in 1850. In the second instance, if any nerve is destroyed by “facet denervation” it is likely not an articular branch, but the medial branch of the dorsal ramus.

Shealy placed electrodes lateral to the “facet,” “near its longitudinal center.” He illustrated the “articular branch” as crossing the superior process at this point. From our anatomical descriptions, it is clear that the articular branches to the zygaphophyseal joint lie rostral and caudal to the joint, not lateral to its “longitudinal center.” The nerve nearest to Shealy’s electrode is, in fact, the medial branch of the dorsal ramus. The electrodes, however, are not placed directly on the nerve. The superior articular process projects rostrally and, therefore, the zygaphophyseal joint lies rostral to the level of the transverse process. Shealy’s electrodes, being opposite the center of the joint, are rostral to the medial branch, which crosses the root of the superior articular process.

Finnnesen illustrated placing the electrodes opposite the rostral tip of the superior articular process. Lora and Long placed their electrodes lateral to the junction of the upper two-thirds and lower one-third of the “facet” joint. Again, both these placements are rostral or lateral to the medial branch.

Another source of error with described techniques is the plane along which the electrodes are introduced. They are introduced sagittally onto the dorsal surface of the zygaphophyseal joint and then “walked” over its lateral edge. Often in lower lumbar vertebrae, the mammillary process and superior articular processes bulge laterally so as to overhang the root of the superior articular process. In such situations, the medial branch, running along the root of the superior articular process is protected from sagittal approaches by the overhanging bone, and electrodes introduced sagittally are displaced laterally from the nerve.

Fox and Rizzoli suggested aiming at “the posterior articular nerve of Luschka,” between the facet joint and the transverse process. Their target point is pictured where the medial branch hooks medially under the zygaphophyseal joint. It is well to avoid this latter point because of the bone variations in this area. Overgrowth of accessory processes produces irregularities in the bone; the mammillo-accessory ligament protects the nerve, and when it is ossified the nerve is inaccessible.

Discussion

The rationale for “facet denervation” is based on the theory that spondylosis or fractures produce “changes” in the zygaphophyseal joints. These changes are the source of patient’s pain. That a patient is suffering from zygaphophyseal joint pain is confirmed by infiltrating the joints suspected of producing pain with local anesthetic, the so-called “facet block.” Relief of symptoms by “facet block” is the usual indication for “facet denervation.” However, because of the anatomy of the nerves innervating the zygaphophyseal joints, it is probably not possible to selectively denervate them with a percutaneous technique. The distal zygaphophyseal nerves are spread so variably over the vertebral lamina that it would require an extensive lesion to reliably destroy them. Such a lesion would necessarily also include the medial branch because of its proximity to the distal zygaphophyseal nerves. The proximal zygaphophyseal nerves are short and lie so close to the medial branch of the dorsal ramus that they could not be destroyed by a radiofrequency lesion without incorporating the medial branch into the lesion. Both sets of articular nerves, however, arise from the medial branch, and if percutaneous denervation of the zygaphophyseal joints is the aim, an appropriate method of doing so would be to interrupt the medial branch. Only open microsurgery, at present, would allow a specific transection of zygaphophyseal nerves.

A corollary to the use of the medial branch neurotomy for the denervation of the zygaphophyseal joints is that, rather than “facet blocks,” blocking the medial branch would be a more appropriate diagnostic test. An appropriate target point for this nerve is where it has a constant course in relationship...
to bone. Bone landmarks are readily identified by fluoroscopy. At the L1–4 levels, the medial branch bears a constant relationship to bone where it runs across the root of the superior articular process. An appropriate target point, then, is the dorsal surface of the root of the transverse process immediately below the most medial end of its superior edge. The nerve is certainly within 5 mm of this point (5 mm is the radius of a typical radiofrequency lesion as described in the literature). At the L-5 level, the medial branch is not suitable for percutaneous radiofrequency neurotomy. At the L-5 level, the dorsal ramus is the target. The target point for this nerve is where it runs along the groove between the ala of the sacrum and the root of the superior articular process.

It is not the purpose of this presentation to discuss the clinical efficacy of this so-called "facet denervation." The results with the techniques described in the literature have varied from excellent to little more than placebo response. One possible explanation of these variations in results may be related to the fact that the anatomy of the area has been poorly understood. The lesions produced would not be expected to reliably denervate the posterior back area. Clinical trials, utilizing these anatomical data, are now under way to compare percutaneous medial branch neurotomy with the results from less specific percutaneous procedures.

Summary

Dissections of the L1–5 dorsal rami were performed in six human cadavers. The course of the dorsal rami and their branches, and the innervation of the zygapophyseal joints were studied and described. The L1–4 dorsal rami divide into medial and lateral branches within the intertransverse ligaments. The medial branches bear a constant relationship to bone: each crosses the most medial end of the superior edge of the transverse process, it then runs across the root of the adjacent superior articular process. At the caudal edge of this process, it hooks medially and is covered by the mammillo-accessory ligament. Thereafter, it crosses the vertebral laminae, passing caudomedially into the multifidus muscle. Beneath the mammillo-accessory ligament, the proximal zygapophyseal nerves arise from the medial branch and innervate the adjacent zygapophyseal joint. The distal zygapophyseal nerves arise from the medial branch as it crosses the vertebral lamina. They innervate the next lower joint.

The L-5 dorsal ramus runs along a groove between the ala of the sacrum and its superior articular process. Opposite the caudal edge of this process the branch divides into medial and lateral branches. The medial branch hooks medially around the posterior lumbosacral joint, which it supplies, and finally ramifies into the multifidus muscle.

On the basis of these descriptions, currently advocated techniques for lumbar "facet denervation" were analyzed, and it was found that they would be unlikely to reliably denervate the zygapophyseal joints. A percutaneous technique for medial branch neurotomy is described and suggested as an alternative.

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