The Role Of Radiofrequency Facet Denervation In Chronic Low Back Pain

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Introduction And Historical Background

Low back pain is one of the most common pain complaints experienced by our population, and has become a major societal and health problem. It is the most frequent cause of activity limitation in people below the age of 45 years, the second most frequent reason for physicians' visits, the fifth most frequent cause for hospitalization, and the third-ranking for surgical procedures.[1] The overall lifetime prevalence of back pain exceeds 70% in all industrial countries. The consequences of this pain include loss of 1.4 working days per person / per year; 10-15% of all sickness absence is related to back pain.[2] Back problems are also responsible for 25% of all disabling occupational injuries, with an estimated 12 million people in the workforce with low back impairment, and 5 million with disability on the basis on back problems.[1]

The exact etiology of low back pain is difficult to diagnose. This may be in part related to the complex structure of the spine. In the early 1900's, dislocation or distraction of the sacroiliac joint was felt to be a common etiology for pain.[3] In 1911, Goldthwait postulated that "the peculiarities of the facet joints" were responsible for low back pain and instability.[4] By the 1920's and 1930's, pathology in the facet joints was gaining ever more popularity as a possible cause of back pain, with introduction of the term "facet syndrome" by Ghormley in 1933.[5] Many studies followed, focusing on this etiology for low back pain. In 1934, however, Mixter and Barr[6] first described herniation of the intervertebral disc as a cause for low back pain and sciatica. This changed the entire focus of treatment for low back pain for the next 30-40 years. It was only as practitioners began to realize that lumbar laminectomy and nerve root decompression were not resulting uniformly in relief of low back pain that attention once again turned to other potential etiologies of low back pain.

Potential sources for low back pain include the supraspinous ligament, the lumbar paraspinal muscles (only after prolonged pressure or stretching, however), the posterior longitudinal ligament, the vertebral body end plates, and the facet joints.[1] Hirsch first demonstrated in 1963 that low back pain could be produced or reproduced by injecting hypertonic saline in the region of the facet joints.[7] Mooney and Robertson confirmed this with intra-articular injections of hypertonic saline in 1976.[8]

Anatomy And Physiology Of The Lumbar Facet Joint

The lumbar facet, or apophyseal or zygapophyseal, joints are formed by the superior and inferior articular processes of successive vertebrae. On the dorsolateral surface of each superior articular facet is a prominence known as the mammilary body or process. There is also an accessory process which arises from the dorsal surface of the transverse process near its junction with the superior articular process. The size of the accessory process varies, and in the lower lumbar region it is frequently quite large, with considerable bony overgrowth of the base.

The nerve supply of the lumbar zygapophyseal joints is derived from the dorsal primary ramus of the nerve root. The nerve which appears to be most closely associated with the joint is the medial branch of the dorsal primary ramus, and anatomical studies have delineated that each zygapophyseal joint receives innervation from two successive medial branches. Bogduk and Long[9] have published an elegant anatomical study using cadavers which clearly establishes the anatomy of these nerves. They note that the lumbar dorsal rami of L1-L4 differ from that of L5. Figures 1 and 2 show a transverse and lateral view of the anatomy being discussed. At the L1-L4 levels, each dorsal ramus arises from the spinal nerve at the level of the intervertebral disc. It enters the back through a foramen in the intertransverse ligament. About 5mm from its origin, the dorsal ramus divides into a medial and lateral branch. The lateral branches continue into the longissimus and iliocostalis muscles of the erector spinae apparatus. The 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 articular process. Here, the medial branch enters a fibro-osseous canal, created by the superior articular process, the transverse process, the accessory process, and the mammillo-accessory ligament. This ligament is often calcified, creating an entirely bony canal.

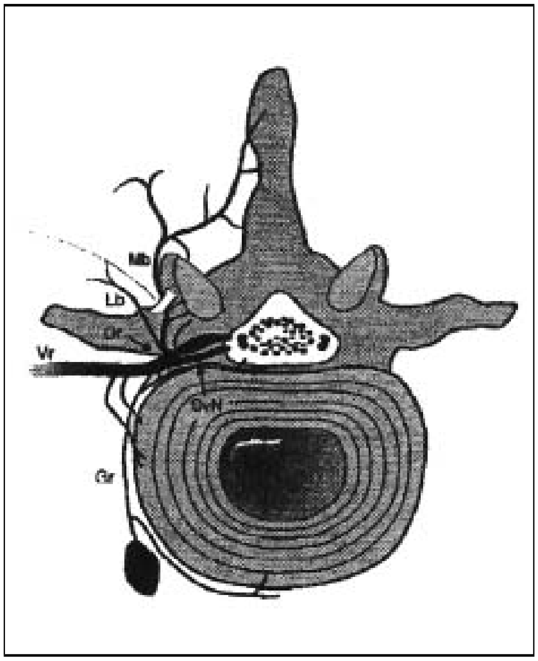


Figure 1. Transverse view. Nerve supply to the lumbar facet joint.

Mb Medial branch of the dorsal primary ramus
Lb Lateral branch of the dorsal primary ramus
Dr Dorsal root
SvN Sinuvertebral Nerve
Vr Ventral root
Gr Gray ramus communicante

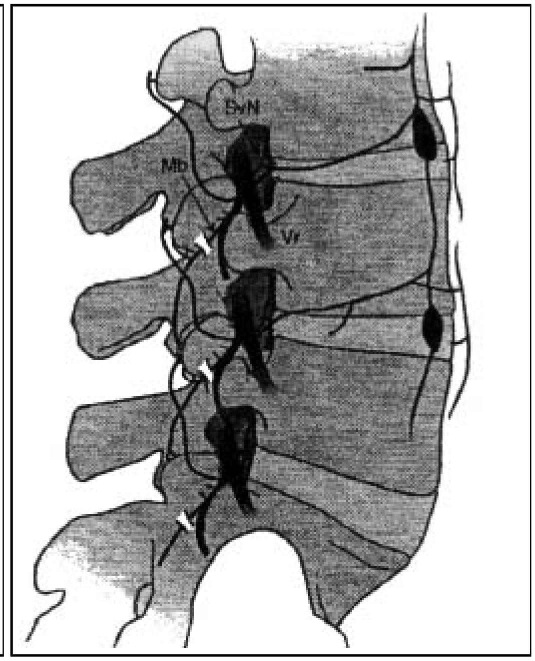


Figure 2. Lateral view. Nerve supply to the lumbar facet joint.

SvN Sinuvertebral nerve
Mb Medial branch of the dorsal primary ramus
Vr Ventral root

Once emerging from this canal, the medial branch runs medially and caudally just caudal to the zygapophyseal joint, and becomes embedded in the fibrous tissue surrounding the joint. It continues across the lamina just deep to the multifidus muscle and sends a branch to the interspinalis muscle, and eventually enters the multifidus muscle. Terminal branches of the medial branch supply the ligaments and periosteum of the vertebral arches and spines.

The medial branch gives off two sets of branches to the zygapophyseal joints, named by Bogduk and

Long the proximal and distal zygapophyseal joints. The proximal zygapophyseal nerve supplies the rostral aspect of the next lower joint. Thus, each zygapophyseal nerve from the medial branch related to it laterally, and the distal zygapophyseal nerve from the next rostral segment. This fact has important implications for facet nerve block and denervation procedures, as both branches need to be blocked or lesioned to completely denervate a single joint.

The course of the medial branch of the dorsal ramus is fixed anatomically at two points: at its origin near the superior aspect of the base of the transverse process, and distally where it emerges from the canal formed by the mammillo-accessory ligament. No reported variations of this anatomy have been found in the literature to date.[9]

At the L5 level, the transverse process is replaced by the sacral ala, and the L5 dorsal ramus arises from the spinal nerve just outside the L5-S1 intervertebral foramen, passing dorsally over the sacral ala in a groove formed by the junction of the ala with the root of the superior articular process of the sacrum. The medial branch arises as the nerve passes in this groove, and then wraps medially around the posterior aspect of the lumbosacral (L5-S1) zygapophyseal joint, terminating in the multifidus muscle.

The biomechanical function of the facet joints is well-recognized. When standing, the lumbar facets carry approximately 16% of the spinal compressive load.[10] They are relatively unloaded while sitting. Yang and King have demonstrated that lumbar facets carry 3-25% of the spinal load in normal conditions, and up to 47% of the load when the facets are arthritic.[11] There is a close relationship between the intervertebral disc integrity, facet loads and spinal degeneration. With disc-space narrowing, as frequently occurs with spinal degeneration, there is increased load in the facet joints, especially in extention.[11-13] The facet capsules are primarily loaded in flexion and in rotation, and thus the facet joints are the primary resistors against rotational or torsional forces.[14] There is controversy as to whether increased loading of facets is a natural function designed to preserve the intervertebral disc, or whether this represents a pathological change capable of giving rise to pain.

The Lumbar Facet Syndrome

Since the introduction of the term by Ghormley in 1933, the lumbar facet syndrome has come to be used with patients whose pain is primarily in the low back. There is frequently referred pain into the groin, hip or thigh, and occasionally even below the knee, although not into the foot. (See Figure 3) Patients characterize the pain as a dull, deep ache which may be difficult to localize. There may be a history of sudden "catching" or "locking" of the back, and many patients report increased symptoms with lumbar extension. Pain is usually aggravated by prolonged standing, and occasionally by prolonged sitting. There is no clear diurnal pattern to the pain. Some patients experience their pain as worse in the morning, associated with stiffness, while others feel worse at the end of the day, after prolonged activity. This pattern is usually typical for each patient, however. There is typically no change in pain with Valsalva maneuvers.

Physical examination frequently reveals tenderness in the paraspinal region, presumably over the facet joints. Range of motion may be decreased in all planes, but typically extension and

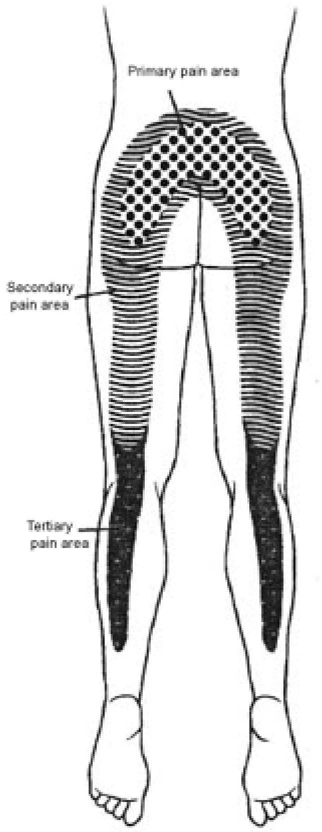


Figure 3. Lumbar Facet Syndrome Pain Referral Map

extension with rotation are most affected, and these movements will frequently reproduce a portion of the patient's pain. Neurological findings are typically absent, and straight leg raising does not produce radicular stretch signs, although it may increase low back pain.

Radiographic evidence is of equivocal utility. Degeneration of the facet joints may be noted on plain films or magnetic resonance images, but often there is no obvious pathology at all. Interestingly, those joints appearing most degenerating on such films may actually be least responsible for pain production, which may be secondary to the fact that movement is completely restricted at that segment.[15]

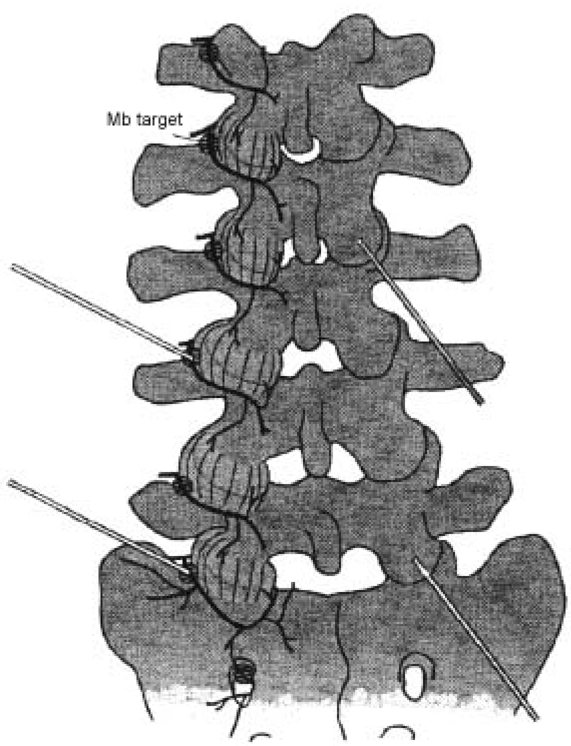
The primary diagnostic test for determining if facet joint pathology is causing or contributing to low back pain has been the injection of local anesthetic into the joint or onto the medial branch of the dorsal primary ramus. Typically, 1-2 ml of local anesthetic is instilled into the joint in questions; larger volumes will cause rupture of the joint capsule, with subsequent extravasation of solution to other potential pain-generating tissues, which makes interpretation of the injection results problematic. The dorsal ramus medial branch is typically blocked with 1 ml of local anesthetic at the superior aspect of the root of the transverse process at the level in question. Blockade of the nerve root may occur with larger volumes or improperly positioned needles.

History Of Facet Denervation

The first report of a surgical technique for prolonging the effect of local anesthetic facet blocks was from Australia in 1971.[16] W. S. Rees described inserting a long knife (a number 11 blade) laterally to the location of the facet, thereby interrupting the sensory nerve supply to the joint. He claimed a success rate of 99.8% in relieving low back and sciatic pain in over 1,000 patients. Shealy attempted to reproduce his results in 1972, with much less success.[17] He noted a success rate of only approximately 50% in 29 patients, and six of those developed significant hematomas in the lumbar paraspinal muscles requiring surgical evacuation. In 1974, Shealy modified Rees' technique by use of radiofrequency electrocoagulation of the target nerves.[17] He noted increased success with this, but still nothing approaching that of Rees. By 1976, he had abandoned this approach in favor of a 0.4% phenol solution injected in the same location.[18] In the same year, King and Lagger demonstrated that Rees' knife blade would have been much too short to reach the innervation of the facet joints, and that what he was performing would more properly be called a myofasciotomy.[19] What is still unclear is why this should have resulted in pain relief.

Bogduk and Long, reporting the results of anatomical studies in 1979[9] and 1980,[20] noted that the target of Rees' and Shealy's procedures was not the articular branches of the facet joints, as described by them, but in actuality the medial branch of the dorsal ramus as it crosses the transverse process, which then gives rise to articular branches as discussed above. Bogduk and Long also noted that of the many studies which reported results of procedures similar to Rees' and Shealy's, few of them placed electrodes or needles in the correct anatomical location necessary to affect the medial branch nerve. They felt that this might account for the failure rate of "facet denervation," as will be discussed below. Following their establishment of the anatomy of the lumbar zygapophyseal nerve supply. Bogduk and Long went on to describe a more anatomically-correct approach to the medial branch of the dorsal ramus, and their approach, with little modification, is that used today.

The Lumbar Medial Branch Neurotomy



With the patient in the prone position on a fluoroscopy table, the transverse processes at the levels to be denervated are identified. (See Figure 4) The introducer cannula is typically inserted in the sagittal plane of the medial branch target one or two levels caudal to the level being denervated, and is then advanced in a rostral and anterior (deep) direction, rather than being advanced from a more lateral position with oblique medial angulation. This is because the effectiveness of the radiofrequency lesion is determined by the configuration of the electrode that is in contact with the medial branch, and the largest electrode contact occurs with the side of the cannula against the nerve, rather than the point. The target of the radiofrequency electrode at the L1-L4 levels is the dorsal surface of the transverse process just caudal to the most medial end of the superior edge of the transverse process.[20] At the L5 level, the target point is the groove between the ala of the sacrum and the superior articular process of the sacrum; this target is actually the dorsal ramus at this level. These target points are readily identified with standard anteroposterior fluoroscopy; however, one must be aware that degeneration of the facet's articular processes, and in particular the accessory process, may cause exuberant bony overgrowth superficial to the target, thus necessitating a more oblique approach to the target point. Shealy described the correct "feel" of the target point as follows:[17]

1. The needle goes no further deeply (blocked by the transverse process);
2. The needle goes no further medially (blocked by the superior articular process);
3. Advancing the needle the slightest bit rostrally allows it to slip off the transverse process and pass

deeply into the intertransverse space;

4. Slowly withdrawing the needle while maintaining pressure directing its tip caudally allows it to slip back into position on the dorsal surface of the transverse process immediately below the superior border.

Once the cannula position appears correct, the radiofrequency electrode is introduced via the cannula. With older systems, the electrode itself needed to be touching bone. With newer systems, utilizing a cannula sheathed with plastic or Teflon with an exposed metal tip of varying length, the electrode need not actually touch the bone, although the exposed tip must. Stimulation is then carried out, using a frequency of 50 Hz and a current up to 1 mA for sensory detection, and a frequency of 2 Hz with current between 3-5 mA for motor stimulation. A positive stimulation is that which reproduces the patient's pain, without producing other sensory or motor findings in the lower extremity or buttocks. Negative stimulation may be failure to produce the patient's pain, or obvious stimulation of motor and sensory structures arising from the spinal nerve. In such cases, denervation should not be performed, and the cannula should be repositioned, followed by repeat stimulation.

Once the stimulation pattern is acceptable, a radiofrequency lesion is created by passing current through the electrode to raise the tissue temperature to 60-80 degrees centrigrade for 60-90 seconds. This portion of the procedure may be quite uncomfortable, and judicious use of sedation and analgesics may be appropriate. Once the lesion is completed, the next level(s) can be treated in a similar fashion. Oudenhoven has reported the potential utility of electromyography post operatively to determine the success of denervation.[22] Shealy correlates this destruction with improved results.[17] Denervation of the multifidus muscle should not be construed as damage to the lumbar nerve root; this may have implications if there is a suspected complication of the procedure.

Complications from radiofrequency lumbar facet denervation are few if the procedure is performed correctly. Most patients will experience significant muscular pain for several days after the procedure. In Burton's study of the procedure published in 1976,[23] there were no infections or adverse neurologic outcomes, and he reported that the only reported complications up to that point in time were generalized reactions to local anesthesia, superficial infections, skin burns from dispersive electrodes, and broken electrodes. The lack of mention of serious complications in subsequent reports implies their absence, although this cannot be deduced from the material presented.

Another clinical entity encountered in some patients is that of post-denervation neuritis. It manifests as what is typically described as a sunburn-like feeling in the paralumbar region, and occasionally radiating into the buttocks. It is usually more annoying than painful, and resolves spontaneously in all cases within six to eight weeks. The exact etiology of this symptom is unclear; hypotheses implicate possible terminal fibers of the medial branch which may supply a small area of skin, or denervation of the lateral branch as well as the medial branch. Some practitioners recommend treating the patient with membrane stabilizing agents such as gabapentin, although in my experience, I have found that patient reassurance as to the benign nature of the finding and its eventual disappearance are equally effective.

Burton also discusses the fact that regeneration of the medial branch nerve most likely occurs following radiofrequency denervation.[23] Clinically, this does not seem to result in significant morbidity, and Burton postulates that in many cases, nerve regeneration is probably hampered by scar formation from the procedure. He does suggest that regeneration of the medial branch may be responsible for return of pain in patients who initially experienced good results from denervation. This is born out by my own clinical experience as well.

Early reports also raised the concern of development of Charcot joints, or joints that have degenerated rapidly secondary to loss of nerve supply. To date, no reports of the development of such complications are extant, and evidence of this process has not been observed in animal models. [23]

I believe it is important for patients to begin a lumbar stabilization program once they have recovered from the discomfort associated with the procedure. A general aerobic conditioning program may also be necessary, given that many of these patients are significantly deconditioned due to restricted activity from prior pain. The goal of this program is to strengthen the supporting musculature of the lumbar spine, so that load is removed from the facets and intervertebral discs as much as possible.

Results of Radiofrequency Denervation

The stated results from lumbar radiofrequency facet denervation have ranged from a dismal 9%[24] to a gratifying 83%.[25] The results of several studies are outlined in Table 1. Comparison between studies is very difficult, as in many of the earlier studies, it is not clear whether an appropriate target was actually used.[9,20] In some cases, it is not clear whether any type of diagnostic block was performed before facet denervation.[3,16-19,22-23,26,29] In the study by Pawl,[21] while the diagnostic test is listed as a medial branch block, this is only surmised, as what he describes is infiltration of local anesthetic around the facet mass. The electrode placement for denervation in this study was also incorrect, being placed just lateral to the facet, with no attempt made to place the tip of the electrode near the medial branch of the dorsal primary ramus.

Table 1. Comparison Of Success Rates Of Facet Denervation Among Various Studies

Author	Year Pub.	n	F/U Time	Diag. Block?	Prev. Oper.	No Prev. Oper.	Success Prev. Oper.	Success No Oper.	Overall Success
Rees [16]	1971	>1,000	?	?	?	?			99.8%
Pawl [21]	1974	50	7-13m	MB*	13	37	11%	55%	
Johnson [3]	1974	87	?	?	?	?			60-74%+
Shealy [17]	1975	207	6-21m	?	?	?	41% fusion 27% lami	79%	
Shealy [18]	1976	29	?	?	?	?			~50%
Burton [23]	1976	126	3y	?	?	?	9%	67%	
King, Lagger [19]	1976	?	?	?	?	?			27%
Lora, Long [24]	1976	119	6-30m	IA#	40	82	27.5%	61%	
Oudenhoven [22]	1977	?	?	?	?	?			63%
Ogsbury, et al [25]	1977	70	13m	MB*	38	33	34%	36%	
Oudenhaven [26]	1979	?	?	?	?	?			83%
Anderson, et al [27]	1987	47	1d - 3.5y	IA#	26	21	15%	19%	
North, et al [28]	1994	82	2y	MB*	56	26			45%
Gocer, et al [29]	1997	46	3m - 3y	?	24	22	62.5%, 41.7%@	63.6%, 36.4%@	

* MB = median branch dorsal primary ramus block
+ "Excellent" + "good" results = 60%; + "fair" = 74%
# IA = intra-articular block
@ first % = immediate results; second % = 3 months later

Burton's study points out an early prognostic factor which has since been disproven.[23] He noted differing success rates according to whether or not the patient had previous back surgery. This phenomenon was also noted in other studies as well.[18,21,24] However, more recent authors[25,27-29] have not been able to document any difference between the two groups. In both Pawl's[21] and Bur-ton's[23] studies, as well as that of Lora and Long,[24] the electrode was placed by advancing it off the lateral aspect of the lower one-third of the facet itself. It is not clear that this would place the electrode near the mammillo-accessory ligament, which may have been calcified in many cases, thus making denervation of the appropriate nerve impossible.

King and Lagger's study[19] population was patients with radicular lower extremity pain rather than mechanical low back pain, and it is thus not surprising that their success rate for achieving pain relief is so low compared to other authors; the most likely etiology for the patients' symptoms would be pathology involving the nerve root, not the facet joint.

There are three studies of note which have been published since Bogduk and Long's description of the nerve supply of the lumbar facet joints and the most appropriate method for denervating those joints.[27-29] The Anderson study[27] is quite interesting, because the success rate was so low compared to the other studies. This appears to again be related to improperly positioned electrodes; they describe sweeping the electrode along the edge of the facet to determine electrode placement for denervation, i.e. there was no attempt to place the probe on the medial branch nerve. The results stated by North[28] and Gocer[29] are quite comparable to those achievable by most practitioners today. In my practice, early data has suggested a success rate of approximately 80% with lumbar facet denervation, utilizing placement of the electrode on the medial branch nerve.

Summary

Despite the mixed results, in part due to the lack of careful placement of the denervation electrode, most authors feel that radiofrequency lumbar facet denervation is a useful tool if patient selection is carried out properly. Patient morbidity is low, and the technical procedure itself is not overly difficult. The variability of success also underscores the fact that patients with chronic back pain represent a heterogeneous group, and that an individualized and flexible approach is needed to optimally manage their pain.

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