Pain Physician, Volume 5, Number 1, pp 83-101
2002, American Society of Interventional Pain Physicians®
ISSN 1533-3159

Focused Review

Review of Chronic Low Back Pain of Facet Joint Origin

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Chronic low back pain secondary to involvement of the facet joints is a common problem. Facet joints have been recognized as potential sources of back pain since 1911. Multiple authors have described distributions of pain patterns of facet joint pain. The facet joints are paired diarthrodial articulations between the posterior elements of the adjacent vertebrae. Lumbar facet joints are innervated by medial branches of the dorsal rami of the spinal nerves from the L1 to L4 levels. At L5, the dorsal ramus travels between the ala of the sacrum and its superior articular process and divides into medial and lateral branches at the caudal edge of the process. Each segmental medial branch of the dorsal ramus supplies at least two facet joints.

The existence of lumbar facet joint pain claims has a preponderance of evidence, even though there are a few detractors. Multiple studies utilizing controlled diagnostic blocks have established the prevalence of lumbar facet joint involvement in patients with chronic low back pain, as ranging from 15% to 52%, based on type of population and setting studied.

Long-term therapeutic benefit has been reported from three types of interventions in managing lumbar facet joint pain, including intraarticular injections, medial branch blocks and neurolysis of medial branches.

This review will discuss chronic low back of facet joint origin and covers anatomy, pathophysiology, diagnosis, and various aspects related to treatment, including clinical effectiveness, cost effectiveness, technical aspects and complications.

Keywords: Chronic low back pain, facet joint pain, facet joint nerve blocks, intraarticular injections, medial branch neurotomy, radiofrequency

Among the chronic pain problems, spinal pain, which includes pain emanating from cervical, thoracic and lumbosacral regions, constitutes the majority of the problems (1). The influence and subsequent financial and social consequences of low back pain have been described (1-33). Indeed, the duration of low back pain and its chronicity have been a topic of controversy and two of the most misunderstood issues in modern medicine. Traditionally, it has been believed that most episodes of spinal pain will be short lived and that 90% of patients with low back pain recover in about 6 weeks with or without treatment (1, 2, 11, 15). However, this widely held misbelief and myth has been dispelled in multiple publications (3, 7, 8, 12, 15-18, 32, 33). These studies showed that chronicity or recurrence of low back pain was 28% to 75%, contrary to the popular belief of 10% to 20%. Among the various painful conditions and structures with potential for producing pain in the spine are intervertebral discs, nerve roots, ligaments, and muscular structures; facet joints have been the subject of most controversy (1, 34-50). The controversy about facet joints is not limited to the prevalence of facet joint pain, and the effectiveness of various modalities of treatments available in managing facet joint pain, but also includes nomenclature. Lumbar facet joints are accepted as potential causes of mechanical spinal pain in the medical literature, based on multiple controlled studies (34-41, 44-50).

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NOMENCLATURE

The facet joint is the nomenclature commonly used in North American literature to describe paired synovial joints between the posterior elements of adjacent vertebrae. Facet joints are also known as zygapophysial joints, apophysial joints, or posterior intervertebral joints. Zygapophysial joints have been spelled *zygapophysial* or *zygapophyseal*. *Facet joint* has been considered as a term which is unsystematic with no formal endorsement (51). It has also been suggested that a facet is simply a small articular surface and, as such, pertains to any small joint, such as those of

the hands and feet (52). The formal term *zygapophysial* stems from the Greek roots, *zygos*, meaning yoke or bridge, and *physis*, meaning outgrowth (52). Nonetheless, *facet joint* continues to be the commonly employed terminology in the United States. The facet joints bridge the vertebrae behind the vertebral foramina. This latter feature distinguishes the facet joints from the joints between C1 and C2 and between C1 and the occiput, which are formally known as the lateral atlantoaxial joints and the atlantooccipital joints, respectively, and the sacroiliac joint.

HISTORY

In 1911, Goldthwait (53) first recognized lumbar facet joints as potential sources of back pain. Goldthwait (53) was impressed by the asymmetry of the facet joints and believed that the joint asymmetry could cause pain resulting from nerve root pressure. In 1927, the Italian surgeon Putti (54) published an article on articular facet degeneration as a cause of pain, which supported the findings of Goldthwait. Subsequently, in 1933, Ghormley (55) first used the term *facet syndrome*, which he defined as lumbosacral pain with or without sciatic pain, particularly occurring suddenly after a twisting or rotary strain of the lumbosacral region. However, Mixter and Barr's (56) description of protrusion of lumbar discs as the most likely etiology of low back pain in 1934 overshadowed the importance of facet joint disorder as a source of low back pain. In 1941, Badgley (57) suggested that facet joints themselves could be a primary source of pain separate from the nerve compression component. He made a plea for continuing focus on the facets in order to explain the large numbers of patients with low back pain whose symptoms were not due to a ruptured disc. In addition, he also showed that facet joint pathology could cause symptoms, including radiation of pain into the lower extremities (57). However, it was not until 1963 when Hirsch et al (58) demonstrated that the low back pain distributed along the sacroiliac and gluteal areas with radiation to the greater trochanter could be induced by injecting hypertonic saline in the region of the facet joints. In 1976 Mooney and Robertson (59) and in 1979 McCall et al (60) used fluoroscopy to confirm the location of intraarticular lumbar facet joint injections in asymptomatic volunteers, demonstrating causation of back and lower extremity pain after injection of hypertonic saline. Marks (61) in 1989 and Fukui et al (62) in 1997 described the distributions of pain patterns and confirmed the findings of previous researchers.

Chronological evolution of chronic low back pain of facet joint origin is outlined in Table 1.

Table 1. *Chronology of evolution of lumbar facet joint pain*

Author(s)	Year	
Goldthwait (53)	1911	Recognition of facet joints as potential sources of back pain
Putti (54)	1927	"Articular facet degeneration" as cause of pain
Ghormley (55)	1933	Used the term facet syndrome
Badgley (57)	1941	Facet joints are source of pain "without nerve compression"
Hirsch et al (58)	1963	Production of "lumbar pain patterns" with injection of "hypertonic saline"
Mooney and Robertson (59)	1976	Production of lumbar pain with "hypertonic saline" and relief with "local anesthetic" injection
McCall et al (60)	1979	Description of lumbar pain patterns in volunteers
Marks (61)	1989	Lumbar facet joint pain patterns
Fukui et al (62)	1997	Lumbar facet joint pain patterns
Schwarzer et al (35, 37)	1994	US prevalence of post-traumatic lumbar facet joint pain - 15%
Schwarzer et al (36)	1995	Australian prevalence of lumbar facet joint pain - 40%
Manchikanti et al (38-40, 44-48, 50)	1999 - 2001	Prevalence of lumbar facet joint pain in US population in interventional pain management setting - 28% to 52%

ANATOMY

The facet joints are paired diarthrodial articulations between the posterior elements of the adjacent vertebrae (63-66). The facet joints are formed by the articulation of the inferior articular processes of one vertebra with the superior articular processes of the next vertebra. The joints exhibit the features of typical synovial joints. The articular facets are covered by articular cartilage, and a synovial membrane bridges the margins of the articular cartilage of the two facets in each joint.

If viewed from behind, the articular facets of the lumbar facet joints appear as straight surfaces, suggesting that the joints are planar. However, viewed from above, the articular facets vary both in shape of their articular surfaces and in the general direction they face (67). In the transverse plane, the articular facets may be flat or planar, or may be curved to varying extents (67).

A tough, fibrous capsule which is composed of several layers of fibrous tissue and a synovial membrane, separated by a layer of loose alveolar tissue, is present on the posterolateral aspect of the facet joint. However, there is no fibrous capsule on the ventral aspect of the joints. Instead, in its place, the ligamentum flavum is in direct contact with the synovial membrane. Facet joints appear to be anatomically designed to restrain excessive mobility and distribute axial loading over a broad area.

The variations in the shape and orientation of the lumbar facet joints govern the role of these joints in preventing forward displacement and rotated dislocation of the intervertebral joint (66). The extent to which a given joint can resist forward displacement depends on the extent to which its superior articular facets face backwards. Conversely, the extent to which the joint can resist rotation is related to the extent to which its superior articular facets face medially (66). Horwitz and Smith (68) described the incidence of flat and curved lumbar facet joints at different segmental levels in the lumbosacral spine. As shown in Table 2, flat facet joints ranged from 19% to 86%, whereas curved joints ranged from 14% to 81% in the lumbosacral region.

Multiple authors (68-77) arrived at different conclusions in the evaluation of facet joint morphology, based on different methods used for quantitative evaluation. Van Schaik (68) concluded that, depending on the method used, the authors arrive at different conclusions as to the morphology of the facets in the transverse plane. Three different methods of calculation of angles with separate connotations have been described (68).

Table 2. *The variations in shape and orientation of lumbar facet joints at different segmental levels*

Joint level	Flat joints	Curved joints
L1/2	44%	56%
L2/3	21%	79%
L3/4	19%	81%
L4/5	51%	49%
L5/S1	86%	14%

Adapted and modified from Horwitz and Smith (67)

Innervation

Lumbar facet joints are innervated by medial branches of the dorsal rami of the spinal nerves from the L1-4 levels. In contrast, the L5 dorsal ramus travels between the ala of the sacrum and its superior articular process, which divides into the medial and lateral branches at the caudal edge of the process, the medial branch continuing medially, where it innervates the lumbosacral joint (78-86). Each segmental medial branch of the dorsal ramus supplies at least two (in humans, monkeys, and cats) or three (in rats) facet joints (87). For example, the L4/5 lumbar facet joint is innervated by the medial branches of the dorsal rami from L3 and L4 spinal nerves in humans.

There is ample evidence showing that the facet joint has extensive innervation of the synovial lining by small, C-type pain fibers (87). Histological studies have shown that capsules of the lumbar facet joints are richly innervated with encapsulated, unencapsulated and free nerve endings (58, 88, 89). Hence, these joints are endowed with the appropriate sensory apparatus to transmit proper inceptive and nociceptive information (88). Multiple studies evaluating the nerve fibers in the facet joints based on their transmitter substance have yielded variable results. It has been reported that protein gene product (PGP) 9.5, substance P, calcitonin gene-related peptide (CGRP), dopamine B-hydroxylase (DBH), vasoactive intestinal polypeptide, neural peptide Y (NPY), and choline acetyl transferase (chAT) immunoreactive (IR) fibers are present within the lumbar facet joint capsule in humans (82, 83, 87, 90, 91). Protein gene product 9.5 is a general neuronal marker, substance P and CGRP are sensory markers

related to pain, DBH and NPY are nonadrenergic sympathetic postganglionic nerve fiber markers in the peripheral nerves, and chAT is a cholinergic nerve marker (92-100). Vasoactive intestinal polypeptide is mainly located in nerves originating from postganglionic sympathetic and parasympathetic neurons but sometimes is located in the neurons in dorsal root ganglia (101). The lumbar facet joint has been shown to receive nerve fibers from dorsal root ganglia and sympathetic and parasympathetic ganglia (87, 102). Suseki et al (87) described that in newborn rats the L5/L6 facet joint was innervated by ipsilateral dorsal root ganglia and paravertebral sympathetic ganglia, segmentally and nonsegmentally. It was also shown that some of the sensory fibers from the facet joint may pass through the paravertebral sympathetic trunk, reaching L1 and/or L2 dorsal root ganglia (87). Suseki et al (87) concluded that inguinal and/or anterior thigh pain with lower lumbar facet joint lesions may be explained as referred pain. Sameda et al (102) showed that 3.4% dorsal root ganglion neurons innervating rat lumbar facet joints also have dichotomized axons projecting to the sciatic nerve. These collateral axons of the dorsal root ganglion neurons into the sciatic nerve terminate in tissues other than the skin, such as muscles or bones. If the innervation found in rats would prove to be the same in humans, the less defined referred somatic pain might be explained by the connection between the facet joint and deep somatic structures via dichotomizing axons (102). Further nerve fibers and nerve endings also have been reported to subchondral bone of the facet joints (88). Such fibers might provide a pathway for nociception from these joints other than from their capsules (88). Multiple variations have been reported in the number and nature of branches of the lumbar dorsal rami that innervate the lumbar facet joints. Occasionally, an articular branch may arise from the dorsal ramus proper and innervate the ventral aspect of the adjacent joint (88, 103). Numerous other variations described in earlier studies have not been confirmed.

McLain and Pickar (104) documented the presence of encapsulated nerve endings in normal human facets from the thoracic and lumbar spine. Freeman and Wyke (105) documented the presence of encapsulated receptors in the posterior elements of the spinal column in 1967, but did not comment on the density of the receptor population or the distribution of the different receptor types. Numerous reviews by Wyke et al (106-110) and Molina et al (111) have alluded to the presence of mechanoreceptors in the human spinal tissue; these reports included micrographs of feline facet tissues, electromyographic data, and direct electrical stimulation of tissues to support these convictions. Next, Giles and Harvey (112) and Giles and Taylor (113) found nociceptive free nerve endings and capsular tissue of human facets and reported similar endings in the facet synovium. Gronbald et al (114) also identified numerous fine nerves traveling with the vessels of the synovial plica and occasional free nerve endings within the synovium. However, neither Giles and Harvey (112), Giles and Taylor (113), nor Gronbald et al (114) reported the presence of encapsulated nerve endings in the facet tissue. McLain and Pickar (104) reported that the nerve endings found in this study were morphologically consistent with descriptions given by Freeman and Wyke (105) and by other authors for cat, dog, and human articular tissues (115, 116). McLain and Pickar (104) concluded that the presence of neural elements within the facet joint capsules proves that some thoracic and most lumbar facets are providing afferent input to the CNS; because the endings identified were primarily mechanoreceptive, it follows that the mechanical status (position, tension, pressure, etc.) of at least some capsules is being monitored at the CNS level. It appears from previous studies that cervical facets contain a consistently greater population of receptors than either the thoracic or lumbar tissues, which is explained by the fact that cervical segments have greater mobility (104). Thus, encapsulated nerve endings are present in the lumbar facet joints, which are believed to be primarily mechanosensitive and to possibly provide proprioceptive and protective information to the CNS regarding joint function and position. It also has been postulated that proprioceptive function in the thoracic and lumbar spine is less refined and, perhaps, less critical than in the cervical spine (104).

PATHOPHYSIOLOGY

As with any synovial joint, degeneration, inflammation, and injury can lead to pain upon joint motion, leading to restriction of motion secondary to pain, which eventually leads to overall physical deconditioning and irritation of the facet joint innervation in itself, leading to secondary muscle spasm. It has been assumed that degeneration of the disc would lead to associated facet joint degeneration and the subsequent low back pain. These assumptions were based on the pathogenesis of degenerative cascade in the context of a three joint complex that involves the articulation between two vertebrae consisting of the intravertebral disc and adjacent facet joints, as changes within each member of this joint complex will result in changes in others in the lumbar spine (117-121). Causes such as rheumatoid arthritis and ankylosing spondylitis, small fractures, capsular tears, splits in the articular carti-

lage, hemorrhage, osteoarthritis, meniscoid entrapment, synovial impingement, joint subluxation, chondromalacia, capsular and synovial inflammation, excessive mechanical injury to the joint capsule, and restriction to normal articular motion from various causes, synovial cysts, and infection have been described as sources of facet joint pain (122). However, radiographic changes of osteoarthritis have been shown to be equally common in patients with and without low back pain, and degenerative joints seen on computed tomography (CT) are not always painful, even though some studies report severely degenerated joints as being more likely to be symptomatic.

The existence of lumbar facet joint pain claims a preponderance of evidence (34-41, 44-48, 50, 58-62, 85, 86, 122-143), even though there are a few detractors (42, 43, 144-146). The estimates of the prevalence of lumbar facet joint pain have ranged from 7% to 75%. Using controlled diagnostic blocks, multiple studies have established the prevalence of lumbar facet joint pain in patients with chronic low back pain to range from 15% to 52%, based on types of population and settings studied (34, 41, 44-48, 50).

PAIN PATTERNS

Lumbar facet joints have been shown to be capable of being a source of pain in the low back and referred pain in the lower extremity in normal volunteers (34, 59-62). However, the lumbar region does not have discrete referral patterns from the facet joints, and the distribution of pain is overlapping from the L1 to S1 levels (61). McCall et al (60) mapped the patterns of pain referral, induced from facet joints in normal volunteers, and concluded that pain referral indicated overlap between the upper and lower lumbar spines (Table 3). Marks (61) also studied patterns of pain induced from lumbar facet joints, from the posterior primary rami of L5 and from the medial articular branches of the posterior primary rami from T11 to L4, and reported no consistent segmental or sclerotomal pattern. However, he also reported that the pain radiating to the buttocks or trochanteric region occurred mostly from the L4 and L5 levels, while groin pain was produced from L2 to L5, concluding that the nerves supplying the facet joints gave rise to distal referral of pain significantly more commonly than the joints themselves. Fukui et al (62), studying the stimulation of the joints from L1/2 to L5/S1 by injection of contrast medium or lumbar medial branches of dorsal rami from T12 to L5 with electrical stimulation, reported similar distribution of referral pain from L1/2 to L5/S1 facet joints and the medial branches of the dorsal rami from L1-5 for each level stimulated, and the overlap of referred pain between each level was considerable. Fukui et al (62) concluded that the major site of referral pain from L1/2 to L4/5 joints was the lumbar spinal region. However, stimulation of the L5/S1 joint caused lumbar spinal pain and gluteal pain. Stimulation of the L3/4 to L5/S1 joint frequently referred pain to the gluteal region, whereas this pattern was uncommon for the higher joints. They also reported that the joints from L2/3 to L5/S1 caused unilateral referred pain in the lateral thigh region, whereas the joints from L2/3 to L5/S1 caused referred pain in the posterior thigh region. In addition, they reported that joints from L3/4 to L5/S1 caused unilateral referred pain in the groin. However, referred pain into the lower extremities was not observed by Fukui et al (62), as

Table 3. *Major pain patterns of lumbar facet joint stimulation*

Joint(s) Stimulated	Pain patterns
L1/L2 facet joints	Central and lateral radiating band of pain
L2/3 facet joints	Mainly lumbar spinal region Occasionally gluteal, trochanteric, and lateral thigh regions
L3/4 facet joints	Mainly lumbar spinal region Occasionally gluteal, trochanteric, lateral thigh, and groin regions
L4/5 facet joints	Mainly lumbar spinal region Occasionally gluteal, lateral thigh, trochanteric, posterior thigh and groin regions
L5/S1 facet joints	Predominantly lumbar spinal region Frequently gluteal region Occasionally trochanteric, lateral thigh, groin, and posterior thigh regions

Adapted and modified from McCall et al (60) and Fukui et al (62)

reported by Mooney and Robertson (59). In summary, referred pain from the lumbar facet joints is predominantly in the buttock and thigh, but pain below the knee can occur, even as far as the foot (59, 60, 92).

DIAGNOSIS

The precise cause of low back pain utilizing clinical history, physical examination, radiological testing, and electrophysiological testing can be identified only in 15% of patients in the absence of disk herniation and neurological deficit (1, 34, 147). However, of all the structures responsible for causation of chronic low back pains - discs, vertebral bodies, nerve root dura, muscles, ligaments, and fascia – facet joints continue to be the most controversial. Kuslich et al (148) identified ligaments, fascia, muscles, intervertebral discs, facet joints, and nerve root dura as tissues capable of transmitting pain in the low back. Bogduk (149) described that any structure with the nerve supply capable of causing pain similar to that seen in clinically normal volunteers, which is susceptible to diseases or injuries that are known to be painful, can cause pain.

The diagnosis of so-called lumbar facet syndrome depends on a clinical presentation with mechanical low back pain described as mainly in the low back with radiation to the buttocks and upper posterior thigh. Some investigators have attempted to identify facet syndrome and predictors of outcome of facet joint injections. Lilius et al (150, 151) evaluated the results of facet joint injections, concluded that the outcome depended on the patient's biopsychosocial ability of self-facilitated improvement, and suggested that the somatic treatment does not work in the presence of persistent high levels of inappropriate signs. However, Wallis et al (152) showed that pain relief that was achieved following radiofrequency facet denervation in the cervical spine not only returned these patients to work, but also resolved all the psychological problems, calling into question the extraordinary attention focused on psychological status. Lewinnek and Warfield (132) considered a negative screening examination for other causes of back pain or sciatica, back pain with tenderness localized over one or more facet joints, and radiologic changes of degenerative joint disease within the facet joints as the most important key factors that characterized patients with a positive outcome. Helbig and Lee (134) described the presence of groin and upper thigh pain, nondermatomal sensory normalities, localized paravertebral tenderness, and reproduction of symptoms with extension and rotation as factors correlating with long-term response to facet joint injections. In contrast, North et al (153) found a statistically significant advantage for patients with bilateral or axial pain complaints and patients undergoing bilateral blocks.

Over the years, multiple investigators have proposed a number of criteria to diagnose facet joint pain without interventions such as diagnostic blocks. However, the situation is complicated by the fact that most maneuvers used in physical examinations are likely to stress several structures simultaneously, especially the discs, muscles, and facet joints, thus failing to provide any reasonable diagnostic criteria. The results of most studies failed to show a correlation between radiological imaging findings and facet joint pain (123, 145, 154-157). Thus, the majority of the reports indicate no correlation between clinical picture, magnetic resonance imaging (MRI), computed axial tomography CT scanning, dynamic bending fields, single photon emission computed tomography (SPECT) and radionuclide bone scanning (1, 34-36, 38, 39, 41, 64, 122, 131, 137, 153, 154, 157-159). A multitude of investigators have attempted to correlate demographic features, pain characteristics, physical findings, and other signs and symptoms with the diagnosis of facet joint pain. Of those, the criteria developed by Fairbank et al (123) and Helbig and Lee (134) are of importance. However, Schwarzer et al (137) evaluated patients with chronic low back pain without history of previous lumbar surgery to test the clinical criteria of Fairbank et al (123) and Helbig and Lee (134) and concluded that these criteria were unreliable in distinguishing pain of zygapophysial joint origin from the pain of other origins.

Revel et al (155) identified patients who responded to single facet joint anesthesia as being more likely to be older, free of pain exacerbated by coughing, well relieved of pain when recumbent, free of pain exacerbated by forward flexion, and without increased discomfort on hyperextension and extension–rotation. Subsequently, Revel et al (156), in another study, prospectively compared the effectiveness of facet joint injection either with lidocaine or saline with and without clinical criteria that were determined in the previous study (155). Revel et al (156) concluded that the presence of five among seven variables distinguishes 92% of patients responding to lidocaine injection and 80% of those not responding to lidocaine. However, Manchikanti et al (40), in a study designed to explore various issues of controversy and to demonstrate correlation or lack thereof with previous investigations, explored various issues, which included the prevalence of lumbar facet joint pain in a consecutive series of patients with chronic low back pain using double diagnostic blocks, and the correlation of clinical features described by various authors of re-

sponders and nonresponders to double diagnostic blocks. Frequency and correlation of criteria in the study by Manchikanti et al (40) compared to a study by Revel et al (156) failed to show any correlation between diagnosis of facet joint pain and confirmation by double diagnostic local anesthetic blocks. Manchikanti et al (40) also showed significant negative correlation with postsurgical patients, patients with a history of occupational injury, and patients experiencing back pain with straight leg raising in the double block – positive group. In addition, they also showed that evaluation of the relationship of physical findings under other features with the characterization and diagnosis of low back pain of facet joint origin, confirmed by double block anesthesia, showed negative correlation with normal gait, negative neurological examination, relief in supine position, and osteoporosis. Overall, they concluded that there were six features that provided negative correlation, as follows: pain not relieved in the supine position, history of surgery, occupational onset, normal gait, positive neurological examination, and no evidence of osteoporosis. However, they also showed that only 7.5% of the patients had at least four of the six features described; thus, making these criteria quite infrequent and unreliable.

DIAGNOSTIC BLOCKS

Bogduk (34) proposed that blocks of a zygapophysial joint can be performed to test the hypothesis that the target joint is the source of a patient's pain by anesthetizing the target joint. Provocation of pain from a joint is an unreliable criterion, and relief of pain is the essential criterion (34). While facet joints can be anesthetized, either with intraarticular injections of local anesthetic or by anesthetizing the medial branches of the dorsal rami that innervate the target joint, true positive responses are secured only by performing controlled blocks. Ideally, controlled blocks should include placebo injections of normal saline, but it may be neither logistical nor ethical to use placebo injections of normal saline in conventional practice in each and every patient (34). In addition, one may be required to perform three blocks of the same joint if a placebo is used. As an alternative, comparative local anesthetic blocks, in which on two separate occasions the same joint is anesthetized using two local anesthetics with different durations of actions, have been proposed (160-162). While comparative local anesthetic blocks may not be implementable for intraarticular blocks, for it is not known whether the placement of the local anesthetic in a relatively avascular environment such as a joint space affects its expected duration of action, they are readily implemented for medial branch blocks (34, 85, 163, 164). The use of comparative local anesthetic blocks has been validated and found to be robust against challenge with placebo (163, 164).

A true positive response to comparative local anesthetic blocks is one in which the patient reports complete pain relief for a shorter duration when a short-acting agent is used, and for a longer duration when a long-acting agent is used. The face validity of intraarticular blocks is self-evident; by infiltrating the target joint with contrast medium, radiography demonstrates that the target joint and only the target joint is infiltrated (34). Studies have shown that cervical and lumbar medial branch blocks have good face validity (34, 85, 86). It was demonstrated that the material injected onto the target points for lumbar medial branch blocks when the appropriate technique is used guards against false-negative responses due to intravenous uptake (85, 86). A false-negative rate of 8% was also reported with lumbar medial branch blocks due to unrecognized intravascular injection of local anesthetic (86). A diagnosis cannot be rendered reliably on the basis of a single block. The false-positive rates have been reported to be as high as 47%, which means that for conditions of low prevalence, out of every three apparently positive responses, two will be false positive (44). Hence, controlled blocks are imperative in every case (34).

While it appears that there is significant agreement among most parties that anesthetization of the joint with relief of pain is the most important criterion, debate continues with regards to the appropriateness of intraarticular injections or medial branch nerve blocks. Simultaneously, the issue of controlled blocks by means of medial branch nerve blocks with two different local anesthetics is a contentious issue in some quarters (34, 85, 86, 141-143, 166). Mironer and Somerville (143), in proposing a protocol for diagnosis and treatment of facet joint pain syndrome with a modified three-step approach, agreed with two-stage diagnostic-therapeutic injections as a compulsory part of facet joint pain management but strongly objected to the consecutive use of short- and long-acting local anesthetics to eliminate false-positive results. Instead, they suggested initial intraarticular injection with local anesthetic and steroid, followed by medial branch block as a second diagnostic injection.

Currently, facet joint injection procedures are the gold standard in the diagnosis of facet joint pain. As shown earlier, radiographs, history, and physical examination, or a combination of these findings, are not specific for lumbar facet

joint pain.

Indications for diagnostic facet joint blocks include low back pain for which no cause is otherwise evident and for which pain patterns resemble that evoked in normal volunteers upon stimulation of the facet joints. As imaging studies provide only anatomic information and cannot determine independently if a particular structure is painful, a normal CT or MRI scan demonstrating disc pathology is not a contraindication to facet joint injection if the clinical evaluation provides sufficient evidence to investigate these joints. Additionally, the absence of degenerative facet joint changes on plain radiographs, CT, or MRI does not contraindicate facet joint blocks. Further, bone and SPECT scans do not need to be normal to allow consideration of the facet joints as potentially painful structures. Similarly, weakness secondary to pain, nondermatomal sensory loss which is mainly subjective, and somatic pain in the extremity also are not considered as contraindications to facet joint injections, as facet joints can cause these symptoms.

Contraindications are quite obvious and include bacterial infection, possible pregnancy, and bleeding diathesis. Relative contraindications include allergy to contrast media or local anesthetics and treatment with nonsteroidal anti-inflammatory medications, which may compromise coagulation, specifically with aspirin (34). However, there is no consensus as to the importance of discontinuation of nonsteroidal anti-inflammatory drugs and aspirin before facet joint injection procedures. Theoretically, nonsteroidal anti-inflammatory drugs may be stopped 2 to 3 days before and aspirin 7 to 10 days before the injection procedures. Patients on warfarin therapy should be checked for prothrombin time (PT) and it should be at acceptable levels. In stopping anti-coagulant therapy, one should take into consideration the risk/benefit ratio and also consult with the physician in charge of anticoagulant therapy. In our practice, we advise the patients to contact the physician in charge of anticoagulant therapy and let him/her make the decision as to the date to stop and for how long. However, prior to facet joint injections a PT is performed. Patients on various other drugs such as low-molecular-weight heparins, (for example, enoxaparin [Lovenox®] or ardeparin [Normiflo®]) or other antithrombotics such as danaparoid Orgaran or it increases the risk of bleeding. Similarly, antiplatelet agents such as ticlopidine (Ticlid®) and clopidogrel (Plavix®) are also relative contraindications. Further, patients with diabetes mellitus should be informed about increases in blood sugar if steroids are used. They also should monitor their blood glucose after corticosteroid injection. Precautions should also be taken by patients with artificial heart valves, who may require the use of antibiotics before and after the procedure, as determined by the treating physician. However, due to sterility and limited injections, preprocedural antibiotics for patients with mitral valve prolapse is controversial.

THERAPEUTIC BLOCKS

Long-term therapeutic benefit has been reported from three types of interventions in managing facet joint pain, including intraarticular injections; medial branch blocks; and neurolysis of medial branches either by means of radiofrequency, chemical neurolysis, or cryoneurolysis.

Intraarticular Injections

Long-term therapeutic benefit has been reported from injection of corticosteroids (123-129, 143), local anesthetics (123, 126), or normal saline (126, 135, 156) into the facet joints. While there is abundant literature describing the effectiveness of intraarticular facet joint injections, the number of available randomized clinical trials is limited to a total of five in the lumbar spine. Hence, in the evaluation of the clinical effectiveness of intraarticular facet joint injections, all five controlled studies and additional uncontrolled studies, are considered (Table 4).

Among all the controlled studies the results were positive in only one study. In contrast, observational evidence was positive in four of the six studies. Among all of the controlled studies, the positive study was by Lynch and Taylor (139). In this study, authors compared intraarticular injection with extraarticular injections. However, they also utilized large volumes of injectate. Among other well-conducted studies, Carette et al (126) studied 101 patients, showing negative results. However, all of the controlled studies faced substantial criticism, ranging from overly broad inclusion criteria of patients with neurological deficits; confirmation of the diagnosis by only a single injection or absence of confirmation of the diagnosis by any type of diagnostic blocks; lack of randomization or inadequate randomization; injection of high volumes of injectate; lack of appropriate follow-up; and, finally, lack of independent or third-party review.

Medial Branch Blocks

The role of medial branch blocks in the diagnosis of facet joint pain has been well described and has been judged to

Table 4. *Results of published reports of effectiveness of lumbar facet joint intraarticular injections*

Study	Study Characteristics	No. of Patients	Drugs Utilized	Initial Relief 1-4 weeks Controls vs Treatment	Long-term Relief Control vs Treatment 3 Months	6 Months	Results
Controlled Studies							
Carette et al (126)	P, PC, RA	101	NS, LA, S	33% vs 42%	N/A	15% vs 46%	Neg
Lynch and Taylor (139)	P, C	50	LA, S	50% vs 92%	62%	56%	Pos
Lilius (135)	P, PC, RA	109	NS, LA, S	N/A	64%	N/A	Neg
Nash (167)	P, RA	66	LA, S	58%	N/A	N/A	Neg
Marks et al (168)	P, RA	86	LA, S	45%	18%	N/A	Neg
Observational Studies							
Jackson et al (145)	P	390	LA, S	29%	N/A	N/A	Neg
Murtagh (133)	P	100	LA, S	94%	54%	54%	Pos
Lippit (129)	R	99	LA, S	51%	51%	14%	Pos
Lau et al (128)	R	50	LA, S	56%	44%	35%	Pos
Desoutet et al (127)	P	54	LA, S	62%	38%	38%	Pos
Mironer and Somerville (143)	P	148	LA, S	28%	28%	28%	Neg

P= prospective, RA= randomized, C= controlled, PC= placebo controlled, R= retrospective, LA= local anesthetic, NS= normal saline, S= steroids;, N/A= not available, VS= versus, Pos= positive, Neg= negative

be superior to intraarticular comparative local anesthetic blocks. However, the therapeutic role of medial branch blocks with various adjuvants has not been well defined. The therapeutic role of medial branch blocks with various adjuvants was evaluated in one prospective, randomized clinical trial (140). However, an additional three studies, which were controlled and randomized, evaluated the role of initial blockade with its therapeutic effect (39, 167, 168) (Table 5).

Only one controlled study by Manchikanti et al (140) studied patients who had a diagnosis of facet joint pain confirmed by controlled, double diagnostic blocks. The patients were randomly allocated into two groups, receiving

Table 5. *Results of published reports of effectiveness of medial branch blocks*

Study	Study Characteristics	No. of Patients	No. of Injections	Initial Relief	Long-term Relief 3 Months	6 Months	12 Months	Results
Manchikanti et al (140)	P, RA	73	1-3	100%	100%	82%	21%	Pos
Manchikanti et al (140)	P, RA	73	1-10	100%	100%	100%	95%	Pos
Manchikanti et al (39)	P, RA, D	180	1-2	100%	NA	NA	NA	Pos
Nash (167)	P, RA, D	66	1	58%	NA	NA	NA	Neg
Marks et al (168)	P, RA, D	86	1	46%	14%	NA	NA	Neg

P= prospective, RA= randomized, D= diagnostic blocks only, Pos= positive, Neg= negative

either therapeutic medial branch blocks with a local anesthetic and Sarapin® or therapeutic medial branch blocks with a mixture of local anesthetic, Sarapin, and methylprednisolone. A total of 73 patients was enrolled in the study. The results of this study showed that patients underwent multiple procedures over a period of 2 ½ years. The mean number of procedures or interventions was 2.5 ± 0.09 from 1 to 3 months, whereas it was 4 ± 0.13 for 4 to 6 months, 6.1 ± 0.21 for 7 to 12 months, and 8.4 ± 0.31 for 13 to 32 months. Accumulative significant relief with one to three injections was 100% for up to 1 to 3 months, 82% for 4 to 6 months, 21% for 7 to 12 months, and 10% after 12 months, with a mean relief of 6.5 ± 0.76 months. There was significant improvement noted in overall health status with improvement not only in pain relief, but also with physical, functional, and psychological status, as well as return–to-work status. Manchikanti et al (140) concluded that medial branch blocks with local anesthetic and Sarapin, with or without steroids, are a cost-effective modality of treatment, resulting in improvement in pain status, physical status, psychological status, functional status and return to work.

Manchikanti et al (39) evaluated the diagnostic validity and therapeutic value of lumbar facet joint nerve blocks with adjuvant agents. The study population consisted of 180 consecutive patients who were divided into three groups, with 60 patients in each group. The facet joints in all patients were investigated with diagnostic blocks using lidocaine 1%, initially followed by bupivacaine 0.25% on separate occasions, usually 2 to 4 weeks apart, with or without the addition of Sarapin and/or methylprednisolone. All the patients who underwent double blocks with a definite response were considered as positive for facet joint mediated pain, yielding a prevalence of facet joint pain in chronic low back pain of 36% on average; however, the duration of pain relief associated with each injection in members of the three groups was significantly different. It was shown that patients who were finally judged to be positive for facet joint mediated pain showed mean cumulative relief with both blocks of 20.6 ± 3.97 days, with a range of 3 to 98 days, in patients receiving local anesthetic; whereas it was 29.6 ± 4.86 days, with a range of 12 to 98 days, in patients receiving local anesthetic with Sarapin; compared to 49.8 ± 9.04 days, with a range of 5 to 160 days, in patients receiving local anesthetic, Sarapin, and methylprednisolone. Thus, this study showed that addition of adjuvant agents, either Sarapin with or without methylprednisolone, increased the duration of relief and retained the diagnostic validity.

Marks et al (168) and Nash et al (167) in two prospective evaluations studied the role of intraarticular injections and compared them with medial branch blocks in managing chronic low back pain. However, the results of both studies were shown to be negative with only short-term response.

All of the trials described above are subject to criticism. The randomized clinical trial by Manchikanti et al (140) is limited by its failure to incorporate a placebo group and to utilize a major instrument to evaluate progress. Other studies by Manchikanti et al (39), Marks et al (168), and Nash (167) were also limited by a failure to incorporate a placebo group, lack of long-term follow-up, and lack of reporting of outcomes.

The analysis of type and strength of efficacy evidence shows that medial branch blocks provide level III (moderate) evidence. Level III - moderate evidence is defined as evidence obtained from well-designed trials without randomization, single group pre-, post-, cohort, time series, or matched case-controlled studies.

Medial Branch Neurotomy

Multiple investigators have studied the effectiveness of radiofrequency denervation of medial branches in the spine. Percutaneous radiofrequency neurotomy is a procedure that offers temporary relief of pain by denaturing the nerves that innervate the painful joint, but the pain returns when the axons regenerate. Fortunately, relief can be reinstated by repeating the procedure. Radiofrequency neurolysis as a treatment of chronic intractable pain began in the early 1930s. Shealy (169, 170) pioneered spinal facet rhizotomy in the 1970s, and Sluijter and Koetsveld-Baart (171) initiated minimally invasive radiofrequency lesioning for pain of spinal origin.

Numerous reports describe the technique and effectiveness of radiofrequency thermoneurolysis (172-195). Success with radiofrequency neurotomy has been reported in the range of 17% to 90% for management of lumbar facet joint pain. There were four prospective studies by Van Kleef et al (141) Dreyfuss et al (142), Gallagher et al (176), and LeClaire et al (195).

Van Kleef et al (141), in a randomized, double blind trial of radiofrequency lumbar facet denervation for chronic low back pain, studied 31 patients with a history of at least one year of chronic low back pain and facet pathology on

the basis of a positive response to a diagnostic nerve blockade. Each patient in the radiofrequency treatment group (15 patients) received an 80° radiofrequency lesion of the dorsal ramus of the segmental nerve roots, L3, L4, and L5. In contrast, patients in the control group (16 patients) underwent the same procedure but without the use of radiofrequency current. The results showed that, 8 weeks after treatment, there were 10 successful treatments in the radiofrequency group and 6 in the control group. After 3, 6, and 12 months, the number of successes in the lesion and sham groups was 9 and 4, 7 and 3, and 7 and 2, respectively. These study results demonstrated that radiofrequency denervation of the lumbar facet joints can be effective for pain reduction in patients with lumbar facet joint pain.

Dreyfuss et al (142) examined the role of lumbar radiofrequency neurotomy for chronic zygapophysial facet joint pain in a pilot study using comparative local anesthetic medial branch blocks. Overall treatment success, defined as 50% or more pain relief at 1-year postneurotomy, was achieved in 87% of patients.

Gallagher et al (176) studied 60 patients in a prospective manner by identifying those who had low back pain for more than 3 months for radiofrequency neurotomy. They used screening blocks as inclusion criteria for denervation with 0.5 cc of 0.5% bupivacaine "into and around appropriate joints" under fluoroscopy. Of the 60 initial patients, 30 patients had a good response, and 11 had an equivocal response. The 30 patients with good response were randomly divided into four groups and received either medial branch radiofrequency neurotomy at 80° C for 90 seconds with active denervation, or a placebo. Statistically significant improvement was shown in the active denervation group compared with the placebo group. At 6-month follow up, however, only 24% of the patients with active denervation and 3% of the patients with placebo showed significant improvement.

In contrast to the above three studies, in a placebo–controlled clinical trial to assess efficacy of radiofrequency facet joint denervation in the treatment of low back pain, LeClaire et al (195) studied 70 patients with low back pain of more than three months' duration and a good response after intraarticular facet joint injections under fluoroscopy. They concluded that even though radiofrequency facet joint denervation may provide some short-term improvement in functional disability among patients with chronic low back pain, the efficacy of this treatment has not been established.

However, all of the controlled studies described above have been criticized for flaws in diagnosis; recruitment and allocation of patients; diagnosis of facet joint pain with single block versus double block; selection of patients with visual analog scores less than 5 of 10; and small numbers of patients included in the studies,; selection bias; and, finally, reporting of the results.

As shown in Table 6, two of the four controlled trials, and the only randomized, placebo-controlled, double-blind study, showed significant pain relief, along with improvement in other parameters, indicating moderate evidence. In addition, evidence from uncontrolled studies also supports the contention that radiofrequency is effective, even though (contrary to the popular belief), controlled trials showed better improvement than uncontrolled studies.

Table 6. *Results of published reports on effectiveness of lumbar facet joint (medial branch) radiofrequency neurolysis*

				Long-term Relief			
Study Characteristics	**Study**	**No. of patients**	**Initial Relief 1-4 weeks**	**3 months**	**6 months**	**12 months**	**Results**
Van Kleef (142)	P, PC, RA, DB	31	67%	60%	47%	47%	Pos
Dreyfuss et al (143)	P, C	15	93%	100%	87%	87%	Pos
Gallagher et al (176)	P, PC, RA	60	42%	NA	24%	NA	Neg
LeClaire et al (195)	P, PC, RA	70	INS	INS	INS	INS	Neg

C= controlled, NA= not available, P= prospective, RA= randomized, PC= placebo controlled, DB= double blind, NA= not available, INS= insignificant, Pos= positive, Neg= negative

COST EFFECTIVENESS

Cost-effectiveness analysis has taken on an increasingly large role in healthcare policy debates about various interventions for managing low back pain. Growing health-care costs and productivity losses, disappointing treatment results, and changing beliefs in health and pain have led to this increasing concern about the amount of money spent on chronic low back pain. In recent years, more and more studies in the field of the management of chronic low back pain have been incorporating cost issues in their analysis (140, 196-209). The outcome measures used in cost-effectiveness analysis studies in chronic pain research mainly include outcomes, such as disability days saved, pain-free days, or improved quality of life, etc., (206); evaluation of the quality of life, which is also known as functional status, health status, or health-related quality of life; well-being of the patient; satisfaction with care and health service utilization/economic analysis; and medical findings (207).

The cost of inpatient chronic pain programs ranges from $17,000 to $25,000, and the cost of outpatient treatment programs ranges from $7,000 to $10,000 (208). In addition, chronic pain patients may incur health-care bills in excess of $20,000 annually for repetitive and, in some cases, redundant diagnostic workups, physical therapy, psychological interventions, and drugs. Guo et al (210) estimated that back pain accounted for 150 million lost workdays in the United States every year, which worked out to be about $14 billion in wage costs alone. The study showed that the magnitude of the back pain problem is so large that even a 1% reduction in overall prevalence could considerably reduce morbidity and save billions of dollars. Malter et al (200) showed that, for carefully selected patients with herniated discs, surgical discectomy is a cost-effective treatment at a discounted cost of $12,000 per discectomy, or $29,000 per life year adjusted for quality. Kuntz et al (205) showed that laminectomy with a noninstrumented fusion costs $56,500 per quality-adjusted year of life versus laminectomy without fusion. The cost-effectiveness ratio of instrumented fusion compared with noninstrumented fusion was $3,112,800 per quality-adjusted year of life (205). However, they also stated that if the proportion of patients experiencing symptom relief after instrumented fusion was 90%, as compared with 80% for patients with noninstrumented fusion, then the cost-effectiveness ratio of instrumented fusion compared with noninstrumented fusion would be $82,400 per quality-adjusted year of life. Mueller-Schwefe et al (201), in evaluating the cost effectiveness of intrathecal therapy for pain secondary to failed back surgery syndrome, compared alternative therapies for achieving a defined outcome, reporting the cost of medical management to be $17,037 per year or $1,420 per month. They also showed that intrathecal morphine delivery resulted in lower cumulative 60-month costs of $16,579 per year, and $1,382 per month.

Lave et al (211) demonstrated the cost effectiveness of medical treatment of depression management as $11,766 per year of quality-adjusted life. It was also shown that a simple reduction of diastolic pressure from 110 to 90 mmHg was achieved at a cost of $16,330 for a 60-year old man in 1974 (207). Total hip arthroplasty for osteoarthritis of the hip costs $61,000 per quality-adjusted year of life gained (212); coronary artery bypass grafting for patients with triple-vessel coronary artery disease and severe left ventricular function costs $41,800 per quality-adjusted year of life gained (213) and surgery to repair a 4-cm abdominal aortic aneurysm costs $21,800 per quality-adjusted year of life gained (214).

The cost-effectiveness evaluation for blind interlaminar, fluoroscopically directed caudal or transforaminal epidural injections for the management of low back pain showed the cost effectiveness of caudal epidural steroids to be $2,550 to $3,635 and that of transforaminal steroids to be $2,927 per year, with a stark contrast with blind interlaminar lumbar epidural steroid injections at $6,024 per year (202, 209). The cost effectiveness of percutaneous adhesiolysis and hypertonic saline neurolysis was demonstrated to range from $2,080 to $5,564 respectively, for improvement of 1 year of quality of life for patients with chronic low back pain nonresponsive to numerous other modalities of treatment (203, 204, 215).

The cost effectiveness of lumbar facet joint nerve blocks was shown to be $3,461 for 1 year of improvement in quality of life (140). Thus, the cost effectiveness of facet joint nerve blocks is in the same approximate range as that of other well accepted modalities of treatment in managing chronic low back pain, but also well within reasonable limits for present-day cost-effective management of other medical conditions. Further, it is also similar to other interventional techniques, excluding surgical interventions.

Cost effective analysis is not available for radiofrequency neurotomy and intraarticular facet joint injections.

CONCLUSION

Based on the present literature, reproducible, controlled analgesic injections appear to be the most scientific method of documenting true facet joint pain. While either intraarticular facet joint injections or medial branch blocks may be used in establishing the diagnosis of facet joint pain, medial branch blocks appear to be more specific, as comparative local anesthetic blocks may not be implemented for intraarticular blocks due to lack of knowledge with regards to the effect of local anesthetic in a relatively avascular environment such as a joint space, and response to placebo injections such as normal saline. Even though there are few detractors of the existence of facet joint pain, it appears that the prevalence of lumbar facet joint pain ranges from 15% to 52% based on types of population and settings studied. Based on the current literature, it appears that initial intraarticular injection of corticosteroids and medial branch blocks with steroids provides short-term relief in most cases, and long-term relief in a few cases. However, the effectiveness of repeat medial branch blocks, following the diagnosis of facet joint pain with double blocks, appears to be promising. It appears that medial branch blocks may be superior in providing longer-term relief considering the ease of technique and slow denervation with repeat blocks. Medial branch denervation appears to be superior to either intraarticular injections or medial branch blocks.

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