

Fusion for Occult Posttraumatic Cervical Facet Injury

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Abstract: Persisting neck pain and headache is a common complication of acceleration/deceleration injury. Seventy patients with normal imaging studies and persisting pain after injury (median 1.7y), who had failed all usual conservative forms of care were offered a diagnostic block protocol to determine the origins of the persisting pain. Blocks included C-2-3 roots bilaterally: C-2-3-4 zygapophyseal joints, and provocative discography at C-3-4, 4-5, 5-6, 6-7. Seventy patients entered the study; 67 completed the block protocol. On the basis of response to blocks, 44 patient were chosen for posterior cervical fusion of C-1, 2, 3, 4 in several combinations. Seventy-nine percent of patients achieved complete pain relief; 14% received satisfactory pain relief; fusion was achieved in 95%. These data support the hypothesis of Bogduk and associates that upper cervical facet injury is a common consequence of acceleration/deceleration accidents. The symptoms can be relieved by upper cervical fusion in some patients selected by concordant blocks.

Key Words: facet injury, fusion, whiplash injury, neck pain, headache, pain relief

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Persisting neck pain and headache is a frustrating complication of acceleration/deceleration injury which has been difficult to diagnose and treat.¹⁻⁴ These injuries are common worldwide.^{5,6} Although persisting symptoms have been linked to litigation in some societies, there is evidence that a significant number of patients have residual disabling symptoms, even in societies where litigation is not a factor.⁷⁻¹¹ These data suggest that patients with symptoms that do not relent within 6 months may have permanently persisting painful sequelae of the injury which are often incapacitating.¹²

Diagnostic information of several kinds has been used to create an extensive list of probable injuries sustained by such patients.¹³ However, little has been

done to clarify which injuries occur in specific patients, because most of the potential injuries are not definable by current imaging studies.¹⁴ For this reason, many have thought the most likely diagnosis for persisting symptoms was psychomatic.¹⁵⁻¹⁷ Causative structural possibilities, most commonly invoked, include injuries to muscles and their ligamentous attachments, facet joint disruption, disc fracture, rupture of the longitudinal ligaments, and rupture of the stabilizing ligaments of the odontoid process.¹⁸⁻²⁰ Bogduk and associates have examined patients with persisting symptoms extensively and have deduced, from the results of diagnostic blockade, that injury to upper cervical zygapophyseal joints and mediation of pain through the second or third upper cervical nerves is a common phenomenon occurring in about half of these patients with upper neck pain and headache.²¹⁻²³ Percutaneous blockade and denervation of the upper cervical joints in such patients produces temporary cessation of symptoms.²⁴⁻²⁷

On the basis of this information, a prospective evaluation and treatment of a group of patients with persisting upper cervical pain and headache after cervical flexion-extension trauma was begun. Evaluation and therapy was based on 3 testable hypotheses: upper cervical facet injury explains a significant number of the complaints of patients suffering from posttraumatic neck pain and suboccipital headache; these patients can be identified by diagnostic cervical blockade; surgical stabilization of the disrupted joints will produce permanent relief of pain.

The Clinical Protocol

To evaluate and test these hypotheses and their null, we developed a prospective paradigm to examine the effectiveness of upper cervical posterior fusion for upper cervical and suboccipital pain with C2-3 dermatomal radiation, and the predictive power of diagnostic blocks to choose patients for the procedure. Adult patients were referred after failure of conservative medical management from either 1 of 2 headache specialists participating in the study. All patients had a history of cervical trauma with complaints of intractable upper neck pain and suboccipital occipital headache with radiation into the second or third cervical dermatomes as described by Bogduk.²⁸⁻³⁰ In 2 patients, there was an associated but separate upper extremity radicular complaint. No patients were entered into the study until at least 6 months had elapsed

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from time of injury. The median time from injury was 1.7 years.

Patient Characteristics

There were 17 men and 50 women. The age range was 27 to 63 years. No one under 18 years was accepted. Patients with demonstrable bony fracture and/or dislocation were not entered. All patients were required to have undergone a physical therapy and exercise rehabilitation program for a minimum of 2 months without improvement in symptoms. Patients had failed all feasible medication trials conducted by 1 of the 2 headache specialists who contributed patients by referral. Fifty-two of 67 patients had failed trials of long-acting narcotics.

Headache and neck pain was bilateral in 64 and unilateral in 3. Pain severity was rated on a 0 to 5 scale proposed by Long, Torgerson, and BenDebba (L TB) and visual analog scale (VAS).³¹ All patients rated pain on the L TB severe—4 (22) or excruciating—5 (45). All VAS scores were 8, 9, or 10 on a 10-point scale.

All patients had significant limitations of cervical range of motion. In all patients, extension exacerbated pain and headache. Nonspecific findings such as local muscle tenderness and painful range of motion were common. However, these musculoskeletal complaints were nonspecific and nondiagnostic. The neurologic examination was normal in all patients.

All patients underwent a standard battery of imaging studies. These included plain cervical spine films with flexion/extension, cervical computed tomography with 2 and 3-dimensional reconstruction and cervical magnetic resonance imaging. There were no imaging criteria for entrance into the study. However, patients with bony fracture, subluxations, cervical disc herniation, or cervical spinal stenosis were excluded from the study and treated separately. Although the expected incidence of nonspecific spondylitic changes were seen, in no patient could a definitive diagnosis of upper cervical spine injury be made on the basis of imaging studies.

Thus, we entered a group of patients who suffered from posttraumatic cervical-suboccipital-occipital headache for a median of 1.7 years after injury and who had failed conventional physical and medical therapies for relief of their headache. No diagnostic physical abnormalities or imaging findings of consequence were present. The physical signs were nonspecific and nondiagnostic. Imaging abnormalities, when found, were considered nondiagnostic of specific upper cervical injury, and within the expected range for age-matched asymptomatic patients.

STUDY DESIGN

The Diagnostic Block Paradigm

All patients were asked to undergo local anesthetic blockade of C-2 and C-3 roots at the neural foramen bilaterally; bilateral C-2-3, C-3-4 cervical zygapophyseal joint blocks with local anesthetic on a separate day; and provocative disc distension with contrast agent at C-3-4,

C-4-5, C-5-6, and C-6-7 on another occasion using the techniques as described by Bogduk.²⁵⁻²⁷ The block sequence was arbitrarily selected by the individuals carrying out the blocks. All blocks were performed under fluoroscopic control by an independent operator, not otherwise involved in the patient's care. The individual performing the block was blinded to the treating physician's assessment of the patient's complaints before choice of levels and test performance. The treating physicians were blinded to the sequence of the blocks until they had been performed. Placebo blocks were not used, but patients were blinded to the level and the nature of posterior blocks and to the levels of anterior disc injection as well as the anesthetic agent. During the performance of the blocks, the operator queried the patient about the provocation of pain during blockade and relief of pain after. These responses were recorded independently. Patients kept a 24-hour log of pain relief, recording their status every 15 minutes while waking. They were then questioned to verify their response by the treating physician. All patients were also queried by a nurse practitioner involved in their care. Identical responses to all 3 assessments were required for the response to be considered valid. Patients rated preblock and postblock pain on a 1 to 10 VAS and similar verbal scale derived by Long, BenDebba, Torgerson.³² Total or near total relief was required for a block to be considered diagnostic. Concordance was recorded, if placement of a needle or injection of the local anesthetic agent reproduced the patient's personal pain and/or total or near total pain relief was achieved by the injection of a local anesthetic. In addition, concordance was accepted only if the pain relief was of the duration expected from the anesthetic agent injected. Failure to provoke or relieve pain and prolonged pain relief were recorded as indeterminate or negative blocks.

Clearly placebo controlled blocks will have greater selectivity and specificity.²⁵ However, both ethical and practical issues led us to choose the paradigm in which the individual doing the blocks did not know the clinical impression of treating physicians and chose the sequence of blocks randomly. The patient knew the general sequence of blocks, but did not know specific structures or levels blocked at any procedure. Three independent records of response were kept to assure the best concordance possible.

RESULTS

Response to Blocks

Seventy patients were offered an opportunity to enter the study. Two patients rejected the block paradigm upon learning the investigative nature of the protocol. One patient found the first block too painful to continue the protocol. All others (67) completed the block paradigm (Table 1). Sixteen patients had negative posterior and anterior blocks. These were eliminated from the surgical treatment option. Two patients had prolonged relief, lasting more than 24 hours from upper cervical root

TABLE 1. Diagnostic Block Results

Structure Blocked	Relief	No Relief
(1) C-2 root only	8	16
(2) C-3 root only	6	16
(3) C-2 and C-3 roots	37	—
(4) C-2-3, 3-4 facets	34	33
(5) C-3-4, 4-5, 5-6, 6-7 Disc injection		
Reproduction of headache	0	—
No reproduction of headache	67	—
Reproduction, cervical radiculitis	2	—

blockade at C-2. These blocks were repeated and were concordant on the repeat in one. The remainder of the patients had concordant blocks of upper cervical nerve roots and/or cervical facets. Eight patients achieved relief with C-2 blockade only, 6 patients with C-3 blockade only, and 37 patients had concordant blocks at both C-2 and C-3. Upper cervical facet blocks achieved pain relief in 34 patients. All patients relieved by facet blocks were also relieved by C2 and/or 3 root blocks. Either facet or root block concordance was considered localizing for the painful segment(s).

Only 2 patients had diagnostic provocative disc injections. Both patients had evidence of single level degenerative disc disease associated with a clearly separable lower cervical radicular syndrome. Thus, no patients achieved concordance with upper cervical pain and headache with a disc injection at C-3-4 or below.

Of the 51 patients who completed the protocol with concordant blocks suggesting upper cervical spine injury, 44 opted for posterior cervical fusion. Four patients elected not to proceed with surgery when told of the indeterminant relationship between positive, blockade and the outcome of surgery. Three patients elected operation, but did not receive approval from the compensation carrier responsible for the cost of their health care.

The Surgery Paradigm

Patients who had total or near total relief of pain with injection were offered posterior cervical fusion if cervical root or zygapophyseal joint blocks were concordant, and anterior cervical fusion if provocative discography was positive at no more than 1 or 2 levels. If C-2 blockade alone produced pain relief, the C-1-2 fusion was recommended. If C-3 blockade reduced pain alone, then C-2-3 fusion was recommended. When both levels were involved, C1-2-3 fusion was recommended. No patients in this study had concordance with provocative disc blockade so anterior fusion was never used for headache in this study. Patients with nonconcordant responses or who did not obtain relief with blockade were not offered surgery and were returned to one of the headache specialists for continued medical management.

All surgical patients were treated with standard Brook's triple wire fusion, as employed by the participating orthopedic surgeons.³¹ Thirty-six patients underwent

fusion of C-1-2-3 by this technique. Two patients underwent fusion of C-1-2 only based on concordant relief from isolated C-2 root block and the absence of any other demonstrable abnormality during intraoperative inspection. Three patients were fused at C-2-3 only, based upon response to isolated C-3 block and the absence of demonstrable abnormality during surgery. In 3 patients C-4 was included in the fusion because intraoperative inspection demonstrated disruption of the joint capsule in 2 patients and, in 1 patient C-3-4 was included because it would have otherwise been an isolated joint above a previous C-4-5, C-5-6 anterior fusion done in another institution.

The surgical procedure was carried out by exposing C-1-2-3-4 through a midline posterior incision in all patients. The surgeon exposed the zygapophyseal joints to their lateral bony margins in all patients and inspected them as soon as they were exposed. The status of the investing zygapophyseal capsule, visible articular surfaces, and stability to manual manipulation were assessed. The capsule at C-2-3 was judged disrupted unilaterally in 6 patients, bilaterally in 30 patients, and in 7 patients no demonstrable capsular or facet injury was seen with posterior inspection. One patient had a bony facet fracture not appreciated on imaging studies.

Of course, the C-1-2 joint cannot be seen by the posterior approach, but the C-2-3, C-3-4 joint capsules could be inspected first when exposed and then if opened in the course of foraminotomy and fusion. All C-1-3 fusions were carried out with 2 individual Sanger cables under the laminae of C-1 and/or C-2, an intraspinal tension band, and transverse cables at each level to be fused to secure half thickness posterior iliac crest grafts supplemented by morselized bone. Foraminotomies were performed at each level to be fused and the joints were opened and obliterated with a high speed drill. Morselized autologous bone was placed at each fused level both in the joint and around the iliac crest joint. All patients were immobilized in a cervical brace when active and a less rigid brace when inactive for three months or until the graft was solidified. An active physical therapy program for neck strengthening and restoration of range of motion and general conditioning was begun in all patients at 3 months or when the graft was solidified in the opinion of the operating orthopedic surgeon.

Thus, demonstrable zygapophyseal joint capsular injuries were present in 78% of patients in the opinion of the 2 surgeons involved. In all but one of the remainder, no visible injury was apparent.

Results: Outcome of Surgery

Relief of upper cervical, suboccipital, and occipital pain was the only goal of the procedure. Pain relief was assessed both on standard 10-point VAS scale and by the 5-point modified scale which uses verbal descriptors.³² Categories are no pain, mild pain, moderate pain, severe pain, and excruciating pain. This scale is similar in intent to the commonly employed VAS, but is easier for patients to apply during telephone evaluation. Both were

TABLE 2. Pain Levels Before and After Surgery

	Levels	Preoperative	6 wk	3 mo	6 mo	1 y*	2 y	3 y†	4 y‡
No pain	1	0	3	6	7	7	7	7	7
Mild pain	2	0	22	22	24	24	24	23	22
Moderate pain	3	0	16	13	10	10	10	10	10
Severe pain	4	11	1	1	1	1	1	2	3
Excruciating Pain	5	33	2	2	2	2	2	2	2

*Between 1 and 2 years, 3 patients developed pseudarthroses necessitating reoperations for recurrent symptoms. Two achieved satisfactory relief at levels 1 to 3.

†Between 2 and 3 years, 1 additional patient developed a late pseudarthrosis and recurrent pain.

‡Between 4 and 5 years, 1 patient developed a pseudarthrosis and recurrent pain.

Categories of no pain, mild pain, moderate pain constitute significant change ($P > 0.01$ χ^2 method) at each time point evaluated.

employed by research personnel unrelated to care on all follow-up visits. Patients were evaluated at 6 weeks, 3 months, 6 months, 1, 2, 3, and 4 years. All patients included in this report were followed for at least 4 years.

Evaluations at 6 weeks and 3 months were still affected by the impact of the surgical procedure and brace wearing. Results are seen in Table 2. Improvements were apparent by 3 months and at 6 months, 41 of 44 patients initially rated their pain moderate, mild, or no pain (93%) on the scale. All patients rated 4 or 5 (severe, excruciating) on the same scale before surgery.

Postoperative VAS scores in these were all below 5. Before surgery all patients rated pain 8, 9, or 10 on the VAS scale. These results were stable for 4 years in all but 5 patients (39 of 44).

At 4 years 39 patients achieved satisfactory pain relief, 88.6%. Five patients were judged to be failures, although 1 underwent refusion for pseudarthrosis appearing after more than 3 years. She is again pain free 1 year later. The others remain failures at 5 years.

These results were achieved without operative mortality or neurologic morbidity. Forty-one patients healed satisfactorily, achieving bony stability as judged by dynamic cervical spine films. In 3 patients initial failure of fusion occurred, necessitating 5 reoperations. In each patient, the first sign of instability was recurrence of pain and in all 3 pain was satisfactorily relieved by refusion. Eventually bony fusion was achieved in 95%. Two patients have returned after 3 and 4 years with a late fusion disruption. Two patients with initially solid fusions continued to complain of severe or excruciating pain.

Additional complications included pneumonia (1), cystitis (2), *Clostridium difficile* diarrhea (1), and tenderness over a cable crimp (1).

The outcome of patients involved in workmen's compensation disability litigation, and other injury

litigation, as shown in Table 3. Four of 11 patients involving workmen's compensation injuries failed to achieve satisfactory relief; no patient reached to mild or no pain category. Of patients involved in other litigation none failed but 6 were still complaining of moderate pain and 16 of mild pain. One patient not involved in litigation failed, whereas 3 achieved mild and 7 were in the no pain categories.

Thus, 36% of compensation patients failed to be benefited. No patients involved in litigation or disability achieved a pain-free state. However, 87.8% of all patients had reduction in symptoms at 4 years to mild/moderate pain level (64% industrial and 100% other litigation).

DISCUSSION

Our diagnostic findings support the hypothesis of Bogduk, Lord and associates that upper cervical facet injuries account for a substantial number of patients with persisting upper cervical suboccipital, and occipital pain after acceleration/deceleration injury.^{1,29,33,34} All of the patients offered surgery achieved temporary pain relief with upper cervical root (C2-3) or upper cervical facet (C2 through C4) blocks. These blocks are not specific or selective enough to ascribe pain to specific structural generators in our opinion. When positive, that is when pain more or less completely relieved, these diagnostic blocks seem to identify painful segments with reasonable selectivity and specificity.^{25,26,35,36} The majority of patients identified through blocks had joint capsular disruption diagnosed by surgical inspection. The attribution of pain to this finding remains correlative for them. For the minority without capsular disruption, no anatomic attributions can be made. However, stabilization of the upper cervical spine relieved symptoms in more than 90% suggesting instability.^{37,38} The positive predictive power of the blocks for the outcome of surgery seems to be satisfactory. Ninety-three percent of patients identified by pain relief after blockade achieved significant pain relief within 6 months of fusion and 88.6% continued to be relieved at 4 years. One additional patient has had recurrence in the fourth year associated with fusion failure and was relieved by refusion in year 5.

None of our patients appeared to have disc injury below C-2-3 as a part of the generation of upper cervical pain. The 2 patients with concordant disc injections had

TABLE 3. Outcome According to Litigation Status at 4 Years

	Workmen's Compensation	Other Litigation	No Litigation
No pain (1)	0	0	7
Mild pain (2)	4	16	3
Moderate pain (3)	3	6	0
Severe pain (4)	3	0	0
Excruciating pain (5)	1	0	1

clearly separable lower radicular syndromes, which would have been diagnosed clinically and with imaging studies in the absence of the block protocol. The C-2-3 disc was not tested for technical reasons. We have no information about the potential contribution of C2-3 disc injury in these patients.

The literature suggests that pain after acceleration/deceleration injury of this type should not be considered persistent in less than 6 months.^{2,12} It was our choice to wait at least 1 year after injury for all patients entered into this study. Traditional symptomatic management has included medication, bracing, traction, restoration of cervical motion, muscle strengthening exercise, and many local passive measures.³⁹ No adequate study demonstrates the value of these conservative measures, but they are standard practice and we arbitrarily accepted patients only after a trial of those conservative measures currently in common use. None of these patients achieved adequate relief with any analgesic medication used by specialists in headache management either.

Other authors have reported different approaches for similar symptoms, including decompression of upper cervical roots, upper cervical ganglionectomy, and rhizolysis of roots and joint innervation.⁴⁰⁻⁴⁵ Lozano and associates⁴⁶ describe ganglionectomy in 22 patients, 13 of whom were similar to our patients, and in 17 patients with spontaneous pain. Unlike our patients, however, 62% of posttraumatic patients had unilateral pain. Success of ganglionectomy was highest in posttraumatic patients. The authors do not comment upon zygapophyseal joint findings. Others have recommended percutaneous denervation of affected joints with successful pain relief for some 9 months.^{47,48} These results offer a less invasive therapeutic option for some patients with symptoms after whiplash.

A comparison of upper cervical fusion, ganglionectomy, and decompression has not been done. The operations are of similar magnitudes and have similar complications aside from potential failure of fusion. Ganglionectomy leaves much of the scalp and ear without sensation and theoretically has a greater potential for development of neuropathic pain. The fusion limits neck motion and has a risk of failure of fusion. Because of the demonstrated capsular injuries and the excellent results in this study, upper cervical fusion is a reasonable choice in patients with appropriate block responses. A comparison of fusion with ganglionectomy and decompression seems warranted to define specific selection criteria for each procedure.

The use of provocative blocks as an indication for surgery is a key issue. It is clear that the best diagnostic block technique would include placebo blocks.⁴⁸ The Bogduk method for concordancy which uses different anesthetic agents with different durations is a reasonable substitute with multiple single blind blocks.³⁵ Determination of concordant reproduction of the pain that any individual patient experiences and the assessment of the actual amount of pain relieved by injection of the anesthetic are both difficult and require skill and

experience. In our patients, the report of pain relief was given to the block operator and recorded subsequently by 2 individuals not associated with the block procedure to maximize consistency of information.

Persisting pain after acceleration/deceleration injuries is a common worldwide problem.^{4,49,50} A significant number of these patients do not improve spontaneously and are not benefited by commonly used conservative treatments.⁵¹ Information from several sources suggest that some of these patients are suffering from undiagnosed upper cervical facet injury. Imaging studies currently available do not define these ligamentous injuries. It seems that the precise application of provocative blockade can identify them with acceptable selectivity and specificity. In our patients identified by a positive response to upper cervical root and/or facet blockade stabilization of the involved segments provided pain relief in the majority. The change in pain scores on both VAS and verbal scales is statistically significant, meaning that upper cervical fusion can provide significant benefits to appropriately selected patients with symptoms serious enough to warrant an operative procedure of this magnitude.

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