Percutaneous radio-frequency neurotomy treatment of chronic cervical pain following whiplash injury

BCOHTA 01:5T OCTOBER 2001

British Columbia Office of Health Technology Assessment
Percutaneous radio-frequency neurotomy treatment of chronic cervical pain following whiplash injury:
Reviewing evidence and needs

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October 2001

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FOREWORD

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The strength of BCOHTA’s method of systematic review lies in the process of explicitly detailing the methodology and criteria used to produce recommendations, which are based solely on the research evidence. This transparent and reproducible assessment process allows other investigators to review the evidence independently and objectively.

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ACKNOWLEDGEMENTS

The observations and suggestions of the following reviewers have been extremely valuable in the preparation of this report, and their contributions are most gratefully acknowledged. Participation in the review process does not imply endorsement, however, and the British Columbia Office of Health Technology Assessment takes full responsibility for the views expressed herein.

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EXECUTIVE SUMMARY

This health technology assessment report critically examines the efficacy, effectiveness, and safety of percutaneous radio-frequency neurotomy (PRFN) treatment of chronic neck-pain following whiplash injury of the neck. The secondary purpose of this health technology assessment is to estimate the provincial population health impact of PRFN.

Key findings

1. Percutaneous radio-frequency neurotomy (PRFN) treatment of chronic pain proven to arise in the zygapophysial joint following whiplash injury has become a new, albeit uncommon, therapeutic option in British Columbia.

2. PRFN treatment has been shown effective versus placebo at relieving chronic pain proven to arise in the zygapophysial joint following whiplash injury, in one double-blind, randomized controlled trial of 24 carefully-selected patients. PRFN provides relief of pain for short to moderately long periods.

3. There is no efficacy or effectiveness evidence from controlled trials comparing PRFN to any alternative therapy to treat chronic neck pain following whiplash injury.

4. The efficacy of PRFN in one highly-specialized setting is promising, but there is an overall lack of evidence of effectiveness. While treatment benefits have been demonstrated in a clinical setting of excellence, realistic concerns must be raised about replicability outside this setting.

5. There are no studies of sufficient sample size to evaluate properly the potential acute complications or potential long-term harm that could result from widespread adoption of PRFN for chronic zygapophysial joint pain.

6. Public policy seeking to balance patient demand against concern about the lack of effectiveness evidence may consider resource allocation for training, accreditation, and limited dissemination, conditional on outcome research.
INTRODUCTION

Whiplash and Whiplash Associated Disorders (WAD) are a significant problem in industrialized societies, and few areas in medicine have generated as much controversy. Issues of litigation and compensation complicate management, and create unique challenges for physicians and other health professionals who treat patients with WAD.

Although the term whiplash was first coined by Crowe in 1928, the intervening years have produced very little high quality research to guide debate in this field. Early work in WAD was almost entirely retrospective and lacked scientific rigor. In 1995, a significant attempt to advance understanding of the problem was made by the Quebec Task Force on Whiplash Associated Disorders (QTF), which undertook a comprehensive review of the existing literature. The QTF findings were not universally accepted, however, and further controversy resulted. Nevertheless, the QTF work established the absence of high-quality evidence supporting diagnosis and treatment of acute neck pain following whiplash injury.

For clinicians, the biggest challenge in whiplash injury is the prevention or management of pain which is termed chronic, that is, of greater than 3 months’ duration. Although a confusing array of treatments is promoted, most of these patients see multiple professionals without achieving definite benefit and at great cost to the health care system. In fact, there is no efficacy evidence for multi-disciplinary teams treating chronic neck pain. Consequently, any treatment shown to be effective in chronic pain following whiplash would be a significant advance.

The present report examines the intervention known as percutaneous radio-frequency neurotomy (PRFN). PRFN is relatively well-known to clinicians as a neuronal lesioning technique, offering temporary effectiveness by denaturing proteins in peripheral nerves, thereby preventing conduction of information along them. In particular, by preventing the conduction of nerve impulses from damaged tissues to the central nervous system, it can relieve pain. Its effects, however, are temporary because the denatured nerves recover in time, and again permit the traffic of sensory impulses that evoke pain. The technique has previously been applied on parts of the nervous system other than in the neck and spine.

In WAD, there has been considerable interest in the role of spinal structures known as the zygapophysial joints. These are paired synovial joints found along the back of the cervical
vertebral column, joining the inferior articular process of one vertebra with the superior articular surface of the next (see 2.3 below). These joints have been considered an important source of pain experienced by whiplash-injured patients. PRFN has therefore been advanced as a temporary means of relieving pain by denature of the nerves supplying the affected zygapophysial joints.

The Insurance Corporation of British Columbia, the major motor vehicle insurance provider in British Columbia, commissioned the BC Office of Health Technology Assessment* (BCOHTA) to conduct an independent assessment of the effectiveness and safety evidence in the use of PRFN for the treatment of chronic neck-pain following whiplash injury of the neck. Of particular interest are the number of patients with chronic cervical pain following whiplash who have z-joint injury; and the number of patients with z-joint injury who are likely to benefit from PRFN.

The study topic met the BCOHTA criteria for priority assessment (Appendix A). The present review was consequently initiated to investigate use of the PRFN technique in the treatment of patients in this group.

* Health Technology Assessment (HTA) determines the validity of the scientific evidence regarding a health technology, and aims to locate it in both medical and social contexts.
1 SCOPE OF BCOHTA REVIEW

1.1 Purpose

The primary purpose of this health technology assessment is to gather systematically and to appraise critically the scientific evidence regarding PRFN, versus:

i) no treatment;
ii) placebo;
iii) other interventions.

The secondary purpose of this review is to estimate the provincial population-health impact of PRFN. The review authors used epidemiological evidence regarding cervical zygapophysial joint injury from insurance and health-data records in order to estimate the number of people in the province with whiplash injury who would fit the eligibility criteria for PRFN. The authors then applied PRFN pain-relief efficacy estimates to this eligible population to estimate the health benefits.

1.2 Research question

*Does scientifically valid effectiveness and safety evidence support percutaneous radio-frequency neurotomy (PRFN) treatment of chronic cervical spine pain arising from zygapophysial joint injury following motor vehicle and other accidents, both in itself and in comparison with alternative invasive and non-invasive therapies?*
2 THE TECHNOLOGY

PRFN of cervical zygapophysial innervation

2.1 Description

PRFN is a palliative treatment for pain, in which heat is delivered by an electrode to a peripheral nerve in order to interrupt its function. It does not treat an underlying cause of pain. The PRFN technique generates multiple localized heat lesions that temporarily denature the nerve. Lord et al explain the basic features of this technology:

“Percutaneous radiofrequency neurotomy employs a needle-like electrode coated along most of its shaft by a thin layer of Teflon. The needle is inserted through the skin and posterior cervical muscles so that its exposed metal tip lies immediately adjacent to the target nerve. Connection of the electrode to a radio-frequency generator and connection of the patient to a ground plate completes the electrical circuit. The high-frequency alternating current causes ionic agitation in the tissue immediately surrounding the exposed metal tip, as the ions attempt to follow the rapidly alternating current. The resulting friction produces heat. The temperature of the metal tip only rises to equilibrium with that of the tissue. If the target nerve is incorporated in the radio-frequency lesion then its component proteins will be coagulated and the distal axon will die. In theory, pain will return when the axons regenerate and nociceptive transduction is reinstated.”

PRFN lesioning therefore requires generation of heat in the target site. Lesions created at 60 to 70 degrees Celsius result in destruction of the nerve axon. In an earlier study, Wegner claimed that the destruction is partial, that is, “highly selective destruction of the A-delta and C fibres (pain), with preservation of tactile and motor innervation.” Other studies, however, have shown that the destruction is widespread, across all diameters of the afferent fibre.

PRFN is used in many sites to create nervous system lesions. These include treatment of chronic and intractable spinal pain (through lesioning of the ventral and dorsal roots, ganglia, and sympathetic chains in the cervical, thoracic and lumbar regions of the spine); and occipital headache.
2.2 PRFN positioning

The medical specialist providing PRFN uses an image-intensifying x-ray machine to direct the electrode tip accurately onto the site where the target nerve lies. The goal is to place the electrode immediately next to a nerve. Figure 1 illustrates problems that occur when electrodes are incorrectly placed perpendicular to a nerve. The radio-frequency current passes into surrounding tissues along the length of the un-insulated portion of the needle, and does not project forward from the tip.12

Figure 1  PRFN Electrode (Bogduk et al12)

Sketches of possible relationships between electrodes and target nerves lying on bone. A: A blunt electrode delivered perpendicularly onto a nerve will not penetrate it. If the nerve is thick, the lesion does not encompass the entire nerve, only the closest, most peripheral portion. B: With an electrode resting on bone immediately next to a small nerve, a lesion may substantially encompass the nerve, but the farther the nerve lies from the electrode, the more likely it is to lie beyond the effective radius of the lesion. C: Epineurium and fascia may be interposed between the tip of an electrode and the target nerve, displacing the nerve beyond the maximal effective distal radius of the lesion.

The size of the lesion depends on the tissue temperature induced. Its width is dependent on the diameter of the electrode, while its length is dependent on the length of exposed cannula.12 Tissue temperature is continuously monitored by the radio-frequency generator. It is important to note, however, that safety is determined almost exclusively by accurate placement of the electrode adjacent to the nerve.
2.3 PRFN of nerves supplying the cervical zygapophyseal joints

The cervical zygapophyseal joints (z-joints), (sometimes known incorrectly as ‘facet’ joints), are paired synovial joints which bridge the vertebrae behind the inter-vertebral foramina. (Figure 2)

**Figure 2  Structure of cervical joint (Lord et al\textsuperscript{5})**

Sketch of a typical cervical motion segment, highlighting the structures of the zygapophyseal joint. IAP, inferior articular process; SAP, superior articular process; JC, joint capsule; FAM, fibroadipose meniscoid; M, multifidus muscle; IVD, intervertebral disc.

![Figure 2](image)

**Figure 3  Vertebra and related nerves – top view (Bogduk\textsuperscript{13})**

The dorsal and ventral roots (rr) of the spinal nerve are enclosed in the dural sac (ds) which blends with the epineurium of the nerve. The spinal nerve divides into a ventral ramus (vr) and a dorsal ramus (dr), whose medial branch (mb) curves around the articular pillar. Prevertebral branches (pv) of the ventral ramus innervate the prevertebral muscles, the anterior longitudinal ligament, and the anterior aspect of the intervertebral disc.

![Figure 3](image)
Z-joint innervation has been extensively studied by Bogduk, and Lord et al. Figure 3 shows a cross-sectional view of vertebrae and related nerves including the medial branch of the dorsal ramus. Figure 4 shows a dorsolateral view. In summary, the z-joints are:

“innervated by articular branches derived from the medial branches of the cervical dorsal rami. The C4-8 dorsal rami arise from their respective spinal nerves just outside the intervertebral foramina, and pass dorsally over the roots the transverse processes. Lateral branches of the dorsal rami enter the lateral and superficial posterior neck muscles (splenius, iliocostalis, and longissimus. … (A)rticular branches arise as the nerve approaches the posterior aspect of the articular pillar. An ascending branch innervates the zygapophysial joint above, and a descending branch innervates the joint below.”

Figure 4  Left cervical dorsal rami & branches – dorsolateral view (Bogduk)

A dorsolateral view of the left cervical dorsal rami and their branches (heavy black lines), in the plane of the multifidus. The lateral branches of the cervical dorsal rami have been cut at their origins. The third occipital nerve (ton) innervates the C2-C3 Z joint as it crosses the dorsolateral aspect of the joint. Alternatively, the communicating branch (c) between the C2 and C3 dorsal rami may innervate the C2-3 joint. Below C2-C3, the deep medial branches (m) send articular branches (a) to the Z joints, and then end in multifidus (M). The superficial medial branches (s) pass deep or dorsal to the semispinalis cervicis (SSCe) to become cutaneous. TP, transverse process of C1; SP, spinous process of T1; gon, greater occipital nerve.
3 THE CLINICAL CONDITION

Chronic cervical pain following whiplash injury

3.1 Definition

The focal condition of the present study is chronic cervical pain due to whiplash injury. The definition of whiplash injury adopted in this review is the widely-cited definition developed by the Quebec Task Force.*

"Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck, it may result from rear-end or side-impact motor vehicle collisions, but can also occur during diving or other mishaps. The impact may result in bony or soft-tissue injuries (whiplash injury), which in turn may lead to a variety of clinical manifestations (Whiplash-Associated Disorders)." 2 (p225)

Barnsley et al distinguish whiplash injury from other forms of injury that may occur through a motor vehicle accident:

"…(W)hiplash is an inertial response of the body to the forces delivered to it, in which the head and neck undergo an excursion, but in which neither the head nor the neck suffer any direct blow. It is the latter feature that distinguishes whiplash from other events that may occur in a motor vehicle accident.\(^\text{15} (p10)\)

The Quebec Task Force also developed useful terminology for the clinical conditions seen in relation to whiplash injury:

"Whiplash-Associated Disorders [WAD] is the term adopted by the Task Force to describe the clinical entities associated with the injury. We propose a classification of WAD on two axes: 1) clinical-anatomic axis, and 2) a time axis." \(^2 (p225)\)

The classification particulars are shown in Tables 1 & 2. In the present review, the focus is on those whiplash injuries classified as Grades I and II, with symptoms persisting beyond 90 days.

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* In 1990, the Quebec Automobile Insurance Society (SAAQ), commissioned a task force on ‘whiplash-associated disorders’ (WAD). The task force (known as the Quebec Task Force [QTF]) was mandated to analyze the existing scientific evidence on whiplash, including diagnosis, treatment, epidemiology and natural history. The QTF conducted a systematic review of published and unpublished studies from 1980 to April 1994.
Table 1  Classification of Whiplash Associated Disorder: Clinical-anatomic axis (Quebec Task Force 2)

<table>
<thead>
<tr>
<th>GRADE</th>
<th>PATHOLOGY</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No complaint about the neck</td>
</tr>
<tr>
<td></td>
<td>No physical signs</td>
</tr>
<tr>
<td>I</td>
<td>Neck complaint of pain, stiffness, or tenderness</td>
</tr>
<tr>
<td></td>
<td>No physical signs</td>
</tr>
<tr>
<td>II</td>
<td>Neck complaints + musculoskeletal signs</td>
</tr>
<tr>
<td>III</td>
<td>Neck complaint + neurological signs</td>
</tr>
<tr>
<td>IV</td>
<td>Neck complaint + fracture or dislocation</td>
</tr>
</tbody>
</table>

Table 2  Classification of Whiplash Associated Disorder: Time axis (Quebec Task Force 2)

<table>
<thead>
<tr>
<th>PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>• less than 4 days</td>
</tr>
<tr>
<td>• 4-21 days</td>
</tr>
<tr>
<td>• 22-45 days</td>
</tr>
<tr>
<td>• 46-180 days</td>
</tr>
<tr>
<td>• &gt; 180 days (classified as chronic)</td>
</tr>
</tbody>
</table>

3.2  Mechanism of injury and initial clinical presentation

Whiplash injury usually follows rear- or side-impact motor-vehicle accidents, but may also occur through a variety of mishaps including those in the workplace.16 (p72) Typically, the injured person occupies the front seat of a stationary vehicle that is struck from behind.

“Injury results when neck musculature is unable to compensate for the rapidity of head and torso movement resulting from the acceleration forces generated at the time of impact ... When the physiological limits of cervical structures are exceeded, anatomical disruption of the soft tissues of the neck (including muscles, ligaments, and joint capsules) results.” 16 (p72)
The clinical picture of whiplash injury primarily includes head, neck, and upper thoracic pain. Teasell & Shapiro characterize the clinical presentation as “remarkably consistent from patient to patient and frequently … complicated by psychological sequelae such as anger, anxiety, depression and concerns over litigation and compensation.”

Barnsley et al provide a summary of published evidence that demonstrates the consistency of symptoms following whiplash injury. “Patients develop symptoms quite soon after whiplash injury, typically within 24 hours … The symptoms of whiplash are dominated by pain in the neck and headache. The second most common symptom is pain in the shoulder girdle, followed by paresthesia and weakness in the upper limbs.”

Teasell & Shapiro describe a typical clinical presentation:

“A delay in onset of symptoms of several hours following impact is characteristic of whiplash injuries. Most patients feel little or no pain for the first few minutes following injury, after which symptoms gradually intensify over the next few days. In the first few hours findings on examination are generally minimal. After several hours, limitation of neck motion, tightness, muscle spasm and/or swelling and tenderness of both anterior and posterior cervical structures become apparent.”

Over time, the constellation of clinical features resolves in the majority of patients (section 6 below). The group of patients considered here are those in whom the pain persists for a minimum of three months.

3.3 Chronic neck pain: mechanism of injury & pathology

In a recent review article of chronic neck pain after whiplash injury, Ketroser summarizes pathological findings of whiplash injury. He notes that whiplash injury has been studied using “mannequins, animals, human cadavers, and live human volunteers, the last an unacceptable option if there is any risk of injury or permanent damage.”

Ketroser (consistently with Bogduk and Yoganandan) argues against what he terms the primary misconception of whiplash injury, that it is due to muscle/ligament strain:

“The predominant medical concept of chronic neck pain from car accidents has been that the forceful extension and flexion of the victim’s head during the accident caused stretching and tearing of muscles and ligaments. The healing of these injuries was believed to produce residual scarring that was ‘irritating, less flexible’ and the source of pain.”
Ketroser explains that, because the force is backward, posterior muscle and ligament structures are relaxed, not strained. Furthermore, he reasons that muscle-ligament injury elsewhere in the body do not result in chronic pain conditions.\(^{18}\) (p51-2)

Instead, Ketroser highlights recent bio-mechanical studies using healthy volunteers, slow impact, and new technology known as cineradiography:

“The cineradiography revealed that, on impact, the thoracic spine was pushed forward by the seat back, accompanied by the adjacent C7 vertebra. The C6 vertebra then rotated backward (extension) independent of the vertebrae above and below. This occurred without the backward translation of the C6 vertebra that accompanies backward rotation during normal cervical extension. The extension without translation forced the inferior articular processes of C6 into the superior articular processes of C7. In addition, the C6 extension stretched the anterior disc annulus between C6 and C7. Once the C6 vertebra impacted C7 at the zygapophysial joint (or z-joint), the same movement began at C5. This process created an S-shaped curvature of the spine that progressed, snakelike, up to C3.”\(^{18}\) (p52)

Lord \textit{et al} \(^{5}\) similarly highlight the bio-mechanical studies using cineradiography.\(^{20}\) These technologically-sophisticated techniques reveal otherwise unrecordable cervical neck motion, occurring in the first few milliseconds (ms) after injury:

“Classic studies showed that, in a whiplash injury, the acceleration-deceleration movements of the neck are typically completed within 250 ms. More recent studies establish the critical period to be as short as 110 ms. The brevity of this period precludes any voluntary or reflex muscle response that might arrest, limit, or control the movements of a cervical motion segment. Without muscle control the normal accurate movement of a cervical motion segment must be disturbed, and the forces to which individual segment are subjected can be resisted only by passive ligamentous elements or bony contact. This sets the scene for a variety of possible injuries.”\(^{5}\) (p307)

This sudden posterior angulation of a vertebra, without glide, results in strain of the anterior disc annulus, while the inferior z-joint facet of the moving vertebrae ‘chisels’ into the surface of the superior facet of the vertebra below. According to Lord \textit{et al}:

“This movement may cause impact fractures of the superior articular surface, or contusion of tearing of the intervening meniscoids of the joint, resulting in intra-articular hemorrhage.”\(^{5}\) (p307)

Lord \textit{et al} cite numerous additional human cadaver and post-mortem studies of motor-vehicle accident victims supporting the presence of z-joint injuries, which they argue are consistent with
pathology found in other joints associated with pain syndromes. They conclude, however, that:

“No clinicopathologic correlates have been explored, let alone established, between the presence of such lesions and whether or not the patient suffered or had suffered pain stemming from the observed lesion.”

Although cervical z-joint injury clearly occurs following whiplash injury, the correlation between rear-impact whiplash injury and chronic clinical pain syndromes remains to be established. The limitation, however, is not with the z-joint paradigm itself. Rather, limitations are due to inadequate means of determining z-joint injury in vivo, and the fact that people with z-joint injury do not come to post-mortem.

It is to be noted, however, that diagnostic blocks have established the z-joint as a source of chronic neck pain. Moreover, outcome research has shown that patients benefit from lesioning of the nerves that supply this joint, along with adjacent structures.

3.4 Diagnosis of chronic neck pain

3.4.1 Anatomic diagnosis

Accurate anatomic localization of neck pain following whiplash remains an elusive goal of imaging studies.

“Radiological studies of the cervical spine taken at the time of the accident are generally unremarkable or reveal evidence of pre-existing degenerative changes … Rarely, x-rays may reveal evidence of bony injury such as posterior joint crush fractures or minimal subluxation. Radiological investigations are of limited value in diagnosis and prognosis and their main use is in ruling out surgically correctable anatomical injuries. Computed tomographic (CT) scanning and MRI should be reserved for cases where cervical disc protrusion or spinal cord injury is suspected.”

Imaging technology is equally of little use in relation to z-joint injury:

“There are no valid and reliable means of identifying symptomatic lesion of the cervical z-joints using currently available imaging technologies. Nothing evident on plain radiographs, computed tomography scans, or magnetic resonance imaging has been shown to correlate with neck pain, let alone Z-joint pain. Plain radiograph, in particular, is conspicuously insensitive.”

Radiographic changes do not provide evidence of the source of pain. No classical changes have been shown to correlate with pain; and moreover, the changes of spondylosis and osteoarthritis have been shown not to correlate with pain. Therefore, even where irregularities are noted in a
joint structure such as the inter-vertebral spaces in the neck, it does not necessarily follow that pain is in fact arising from that structure.

Further research is needed to correlate morphologic evidence of z-joint injuries with responses to anaesthetic nerve and z-joint blocks.

### 3.4.2 Physiological diagnosis

Because the z-joints lie deep in the neck, they cannot be inspected, their movements cannot readily be observed, nor can they be palpated reliably. Consequently, cervical z-joint pain cannot be diagnosed on the basis of physical examination, nor indeed can any other source of neck pain be diagnosed by physical examination. The physician can, however, determine the presence of z-joint pain, and identify which z-joint is involved by injecting local anaesthetics either into individual z-joints or to the nerves that supply those joints.

For intra-articular z-joint injections, patterns of pain have been studied in normal volunteers. The cervical z-joints produced local and referred pain patterns similar to those seen in patients with neck pain. These studies have resulted in pain referral maps which are used to identify the segmental levels for further investigation. Other studies have shown that local anaesthetics in the z-joints abolishes the pain for the duration of action of the anaesthetic agent.

In addition to intra-articular injections, temporary nerve blocks with local anaesthetics are also extensively used to evaluate pain problems in the lumbo-sacral and cervical spine regions. The selectivity of medial branch blocks depends on the local anaesthetic effect on the medial branch nerve, as opposed to its spread to adjacent structures. In the Cervical Spine Research Unit in Newcastle, Australia, the specific nerve-block effect was studied in detail in 16 patients.

Clinical experts identify distinct advantages of nerve block versus intra-articular injections to determine the anatomical source of pain:

“The advantage of medial branch blocks is that they are easier to perform than intra-articular blocks, they require less time, and they do not involve the puncture of joints. Consequently, they are eminently suitable for a screening test when the actual source of pain is not known, obviating the need to puncture unnecessarily joints that are normal and asymptomatic.”

The Australian centre strongly promotes diagnostic nerve blocks as necessary diagnostic procedures. Other researchers rely on non-invasive, clinical diagnostic criteria in therapeuti
decision-making. In contrast to the Newcastle group, however, none of the alternate diagnostic strategies have been tested in a controlled trial.

As discussed below, whether diagnostic anaesthetic blocks are used or not, strict, replicable diagnostic procedures are necessary to develop, evaluate, and replicate a treatment program.

### 3.4.3 Nerve block diagnosis

The Cervical Spine Research Unit has investigated radiologically-controlled blocks of the medial branches or the cervical dorsal rami prior to PRFN. In this diagnostic and therapeutic program, the primary concern is to minimize false-positive results. False-positives could lead to unnecessary and ineffective invasive procedures. The studies have therefore been designed to determine the highest level of specificity, accepting the cost to sensitivity.*

Barnsley et al published two reports using a comparative-block diagnostic design. In both instances, the patients were enrolled in larger, ongoing studies of chronic neck pain following motor-vehicle accident. Barnsley et al determined the false-positive rate using a double-block procedure, employing two anesthetic agents differing only in their duration of action. (Figure 5) True-positive patients were defined as those identifying both the longer and shorter acting agents correctly. False-positive patients were those who incorrectly identified the longer acting agent. Pain duration was determined by a researcher blinded to patient allocation.

The first study determined the false-positive rate in 55 patients (60 joints, 5 patients providing two joints) with chronic (greater than 3 months’) cervical neck pain following motor-vehicle accident, and referred to the Cervical Spine Research unit. All of these patients had ‘complete or definite’ relief of their segmental neck pain with the first injection, either short acting lidocaine or longer acting bupivacaine, determined randomly. The authors do not report the total number of patients ‘screened’ to obtain these 55 study patients. After a minimum interval of 2 weeks, they received a second injection with the other agent. If a joint was negative, the procedure was repeated at another, usually adjacent joint. The study included all cervical segmental levels from C2-C3 to C5-C6.

The authors calculated that, if they had chosen patients for PRFN based on their initial response to an anaesthetic, they would have had a false-positive rate of 27% (16/60). True-positive tests were

* Formally, false-positive and false-negative results are tied to the terms specificity and sensitivity. Specificity would here be defined as the probability of a negative block result in patients who do not have pathology in a zygapophysial joint. Sensitivity would correspondingly be defined as the probability of a positive block result in patients who do have zygapophysial pathology.
those in which the patient correctly identified the length of anaesthesia, using a second agent.\textsuperscript{31} They conclude that “(u)ncontrolled diagnostic blocks are compromised by a significant false-positive rate that seriously detracts from the specificity of the test.”

**Figure 5  Positive blocks (Barnsley et al\textsuperscript{31})**

*Segmental levels of responses to controlled diagnostic blocks. False-positive responses represent those initially positive blocks that did not meet the diagnostic criteria for true-positive responses after a control block.*

In the second study, Barnsley et al\textsuperscript{32} tested the hypothesis that comparative anaesthetic technique had discriminatory value above chance. Similarly to the first study, they investigated the diagnostic decision for 49 patients with chronic (greater than 3 months’) cervical neck pain following motor vehicle accident referred to the Cervical Spine Research Unit. They reasoned that “only patients with longer responses to the longer-acting anaesthetic would be considered true-positive responders, and hence be diagnosed as having cervical, zygapophysial joint pain”.\textsuperscript{32} Although including patients with C2-C3 level pain, the actual number of joints affected at this level is not reported.

The study found that using a second, blinded and randomized anaesthetic as a control led to an interesting and unexpected level of complexity. The second agent was meant simply to confirm the validity of the first agent, according to duration. However, the authors found several patterns emerged. In 75\% of cases, the patients successfully identified the correct agents according to...
duration. However, the other 25% had effects which they defined as ‘discordant’ (longer pain relief from lidocaine) and ‘discrepant’ (pain relief from the first, but not the second injection). They conclude that this technique provides a reasonable alternative to saline-placebo controls. They state:

“The use of comparative local anaesthetics blocks circumvent the problem of using normal saline controls. The investigation can be completed within two blocks -- an initial and a confirmatory block, with the control being provided by the different duration of action.”

The Cervical Spine Research Unit tested the reliability of combined anaesthetic blocks versus placebo blocks in a subsequent diagnostic study. This randomized, double-blind study compared saline-placebo injections with a combined anaesthetic injection program. The authors studied whether the selected joint was the source of neck pain in 50 patients. The authors state that, in their opinion, placebo-controlled patient assessment is the gold or criterion standard for pain theory if the pain is of organic origin:

“If pain is of organic, nocioceptive origin, then it should be relieved when the nerve supply to the painful structure is blocked by local anesthetic, the relief should be reproducible whenever these nerves are blocked by local anesthetic, and the relief should not be reproduced by injection of a placebo agent.”

The first step involves injecting one of two (lidocaine 2% or bupivacaine 0.5%), randomly-selected anesthetic agents to determine if the anatomical structure is the source of pain. That is, if the patient reports no benefit then the diagnostic procedure typically stops. This may represent a technical failure or a false-negative finding, which could be re-tested in a subsequent procedure. Typically, however, a particular investigative sequence ends if the subject experiences no relief.

Positive results would then need two subsequent injections, one with either the other active agent and/or with placebo, again randomly-selected. All patients, therefore, required triple blocks. The entire study sequence is described as ‘strictly double-blinded’ although details were not provided as to how this was achieved, nor were patients or the investigator tested to determine the degree of success of blinding. A positive response to a block was reported only if a patient had ‘complete’ or ‘profound’ improvement in pain.

Therefore, while the sensitivity is poor, the specificity is adequate. That is, relatively few false-positive results would lead to unnecessary neurotomy. Table 3 summarizes the diagnostic test characteristics based on the study by Lord et al.
Table 3  Validity of diagnostic decisions based on comparative blocks (Lord et al \textsuperscript{33})

<table>
<thead>
<tr>
<th></th>
<th>Placebo blocks (gold standard test)</th>
<th>Comparative blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>+</td>
<td>26 (a)</td>
<td>6 (b)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32</td>
</tr>
<tr>
<td>-</td>
<td>22 (c)</td>
<td>46 (d)</td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

+ = positive  - = negative

**Prevalence** = \( \frac{(a + c)}{N} = \frac{(26 + 22)}{100} = 48\% \\
overall known probability prior to the test that a patient from this population is positive

**True positive rate (sensitivity)** = \( \frac{a}{(a + c)} = \frac{26}{26 + 22} = 54\% \\
proportion of positive patients correctly identified by the comparative test

**False positive rate** = \( \frac{b}{(b + d)} = \frac{6}{6 + 46} = 12\% \\
proportion of negative patients incorrectly identified by the comparative test

**True negative rate (specificity)** = \( \frac{d}{(b + d)} = \frac{46}{6 + 46} = 88\% \\
proportion of negative patients correctly identified as being negative by the comparative test

**False negative rate** = \( \frac{c}{(a + c)} = \frac{22}{26 + 22} = 46\% \\
proportion of positive patients incorrectly identified by the comparative test as being negative

**Positive likelihood value** = \( \frac{a}{(a + c)} = 0.54 \text{ divided by } \frac{b}{(b + d)} = 0.12 = 4.5 \\
expresses the odds that the given level of a diagnostic test result would be expected in a patient with the target disorder.

**Negative likelihood ratio** = \( \frac{c}{(a + c)} = 0.46 \text{ divided by } \frac{d}{(b + d)} = 0.88 = 0.52 \\
expresses the odds that the given level of a diagnostic test result would be expected in a patient without the target disorder.
In summary, the above studies provide valid scientific evidence regarding the sensitivity and specificity of clinical diagnoses of segmental z-joint injury using comparative and placebo-controlled medial branch nerve blocks, in the patient group studied. These diagnostic test parameters are important in the remainder of this review, both because they are an essential component of the PRFN outcome study, and because they determine who is eligible for that procedure.

It is important to note that these diagnostic test parameters apply only to a population similar to that referred to the Cervical Spine Research Unit in Newcastle. That is, the patient population must be several months post-injury, be referred by a specialist, and have a positive response to initial z-joint anaesthetic block.

3.5 Summary of test parameters for diagnosis

The reported studies\textsuperscript{31-33} demonstrate that different diagnostic programs result in different patient populations subjected to PRFN. As the methodological rigor is diminished, test parameters worsen. The most significant clinical trade-off occurs between sensitivity and specificity. Accepting a lower diagnostic rigor serves to include more patients (increasing sensitivity towards 100%), but at the cost of specificity and therefore with a decrease in the success rate. (Table 4)

<table>
<thead>
<tr>
<th>Diagnostic Test</th>
<th>Percentage of test-positive patients with z-joint injury (specificity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>no anaesthetic nerve block</td>
<td>50%</td>
</tr>
<tr>
<td>(referral population)</td>
<td></td>
</tr>
<tr>
<td>single block</td>
<td>73%-75%</td>
</tr>
<tr>
<td>comparative (double) block</td>
<td>88%</td>
</tr>
<tr>
<td>comparative, and placebo</td>
<td>approaching 100%</td>
</tr>
<tr>
<td>(triple) block</td>
<td>(gold standard test)</td>
</tr>
</tbody>
</table>
4 SYSTEMATIC REVIEW METHODS

4.1 Efficacy, effectiveness, and safety of PRFN

A systematic review was conducted aimed at identifying the available scientific evidence on effectiveness of PRFN.

4.1.1 Search strategy

Relevant studies were identified by searching computerized bibliographic databases covering traditional medical literature: Current Contents, Embase, HealthStar, and Medline. A search protocol designed to identify primary analyses was combined with terms specific to chronic cervical zygapophysial pain and percutaneous radio frequency neurotomy.

A fugitive information search was also conducted to identify the published and unpublished scientific literature not appearing in peer-reviewed journals or not indexed in commercially available databases.

A comprehensive search strategy was developed. The protocols for conventional and fugitive searches are fully detailed in Appendix B.

4.1.2 Preliminary screening

The search results were reviewed independently by two reviewers, and the inclusion criteria stated below were applied to each article. Where differences arose as to whether an article was relevant to the review, disagreements were resolved by discussion. All articles that appeared to meet the criteria were requested in full text form.

The following initial inclusion/exclusion criteria were applied to the PRFN studies identified in the search:

Population of interest

Human populations diagnosed with whiplash injury with or without specifically-diagnosed zygapophysial joint pain, whether or not the diagnosis is proven with local anaesthetic injection into nerves supplying the painful joint(s). No exclusion was made due to co-morbidity.
**Intervention**
Interventions described as percutaneous radio-frequency neurotomy or alternative cervical neural lesioning techniques.

**Outcome measures**
The analysis must report at least one measure relating to a health outcome. A health outcome is “a change in a patient’s current health status that can be attributed to antecedent health care.” Such health outcomes might include:

- the severity of suffering, disability, and mortality,
- the degree of net benefit provided to patients with respect to these parameters by the treatment; and
- prognostic variables associated with the degree of benefit.

**Patients**
Subjects of any age or ethno-cultural group, treated for persistent cervical pain following whiplash associated with motor vehicle or other accident.

**Language**
All languages were included.

### 4.1.3 Critical appraisal inclusion criteria
All randomized controlled trials and controlled trials were included in the appraisal if they:

- compared any form of percutaneous radio-frequency neurotomy;
- used any type of control interventions including placebo, another intervention, or no intervention; and
- reported at least one health outcome measure; and
- had a minimum observational period of 4 weeks.

### 4.2 Epidemiology of whiplash
To understand the impact of the adoption of this technology in British Columbia, a review of the literature on the epidemiology of whiplash was conducted. Because the Quebec Task Force (QTF) undertook a thorough review of the epidemiologic literature through to September 1993, our review included the findings of the QTF report, and of relevant studies published after September 1993.
4.2.1 Preliminary screening

The search results were screened independently by two reviewers, and the following criteria for inclusion or exclusion were applied to each article:

1) studies examining incidence or prevalence of whiplash or the time to recovery of subjects with whiplash;
2) study subjects suffered a neck injury in a motor vehicle accident (other causes excluded);
3) study subjects were diagnosed with, or had symptoms typical of WAD grades I or II (grades III or IV excluded) (Table 1);
4) single case studies were excluded;
5) laboratory and simulation studies were excluded.

All articles that appeared to meet the criteria were requested in full text form.

4.3 BCOHTA critical appraisal methods

The project steering committee endorsed and supplemented the standard BCOHTA methodology. Studies meeting the selection criteria were appraised using the standard BC Office of Health Technology Assessment Intervention Study Appraisal Form (Appendix C). Eligibility was assessed by two independent reviewers. Disagreements were documented and resolved by discussion. The same procedures were followed for the subsequent steps (i.e. information on patients, methods, interventions, outcomes, and results was extracted independently by at least two reviewers).

4.4 BCOHTA expanded evaluative framework

An expanded evaluative framework has been developed to assess the scientific evidence put forward in support of neurotomy testing and treatment strategies along seven dimensions: i) the population at risk; ii) test performance; iii) clinical management; iv) health outcome measures; v) population health impact; vi) economic impact; and vii) social impact.

Within this broader evaluative context, a three-step framework is considered an appropriate basis for evaluation of outcomes. (Figure 6)
In this construct, evidence is needed to link a test result, first to a change in clinical management, and subsequently to improvement in health status. Each step requires an examination of the evidence (or its absence), supporting progress from one step to the next. Clinical effectiveness is thereby dependent on a sequence: an accurate test performance should produce a test result which in turn produces a change in patient categorization; the more accurate categorization must lead to a change in clinical management, which ultimately changes health-status outcome.
5 CLINICAL EFFECTIVENESS & SAFETY FINDINGS

Following the preliminary screening, articles were selected and retrieved in full text form. These are listed in Bibliography I.

Only one study, Lord et al (1996),\(^{28}\) met the minimum inclusion criteria as a controlled trial, and this study was critically appraised. An additional publication, Wallis et al (1997),\(^{35}\) provides further details regarding psychological outcome, based on data from Lord et al.\(^{28}\)

Ten observational studies excluded from critical appraisal are listed in Appendix D, along with their study features and findings. No studies were found comparing PRFN with alternative methods of treatment.

5.1 LORD et al (1996)\(^{28}\)

5.1.1 Critical appraisal results

Purpose
The purpose of this study was to conduct a controlled trial of percutaneous radio-frequency neurotomy for chronic cervical zygapophysial joint pain following whiplash injury due to motor vehicle accident.

Patient selection

Minimum inclusion criteria
- cervical pain > 3 months
- attributable to motor vehicle accident
- failure of conventional therapy (drugs, physiotherapy) and referred to research unit
- C3 to C6 z-joint pain, not C2-C3 level pain

Z-joint diagnosis
- Pain from a z-joint was confirmed with placebo-controlled, comparative (lidocaine 2% and bupivacaine 0.5%) diagnostic blocks of the medial branches of the two dorsal rami supplying the presumably affected z-joint (triple block technique)
- pain confirmed “only if the patient had complete relief of pain each time a local anaesthetic was used, but no relief when normal saline was used”
- all blocks performed under strict double-blind conditions
- one surgeon (same as treatment surgeon) performed all pre-operative assessments
Design

- randomization based on computer-generated random numbers
- sham machine use, double-blinded procedure, same PRFN needle insertion technique

Operative technique

- “One surgeon performed all the operations and made all the preoperative and postoperative assessments”\textsuperscript{28} (p1722)
- each of the two nerves supplying each z-joint was treated twice using different needle insertions and subjected to multiple PRFN lesions

Outcome assessments

1) 100 mm visual analogue, pain scale
2) McGill Pain Questionnaire
3) activities of daily living
4) SCL 90 R checklist of psychological distress

Post-op assessment schedule

- telephone: 3-5 days and 2 to 3 weeks, post-op
- formal interview: 3 months (McGill Questionnaire and visual analogue scale)
- estimate duration of pain relief
- if pain relieved to 3 months, asked to call when pain returned to 50% of pre-operative level, also formal interview at 12 months and annually thereafter.

Definition of successful treatment

- defined as complete relief from pain (0-5 on 100 point visual analogue scale), and 3 words or less on McGill questionnaire, and restoration of all 4 activities of daily living identified as lost; and
- negative answers to: ‘Is your usual pain present?’ and ‘Do you require further treatment?’

Statistical analysis

- Kaplan Meier survival curves; Mantzel-Haenszel test of significance.

Patients included

- 54 patients screened
- selected, N = 24 (9 men, 15 women)
- mean age 43
- median duration of pain 34 months
  - controls IQ range 25-92
  - Tx group IQ range 23-94
  - overall, < 6 patients had symptoms < 2 years
- baseline differences (not statistically significant), but differences noted by researchers:
  - sex M/F: active = 5/7; control = 4/8
  - litigation: active 4/12; control 10/12
- 17 patients = unilateral and one z-joint level (3 treatment, 4 control had more than one joint)
Post-operative assessment

- numbness or dysesthesia in cutaneous territory of coagulated nerves T = 5; C = 0; no patient required treatment, but note that numbness is a potential threat to blinding as to treatment allocation.
- return to accustomed pain immediately post-op: T = 3; C = 6
- post-operative pain relief: T = 9/12 (75%) C = 6 (50%)
- pain free at 27 weeks: T = 7 (58%); C = 1 (8%)
- median time to return 50% of preoperative pain: T = 263 days; C = 8 days (p=0.04)
- in all cases pain ultimately returned
- the response to treatment was not affected by the presence of litigation

Second procedures

- 5 patients in each treatment group underwent second procedures
- 3/5 in active treatment group with pain relief < 3 months had no relief with second procedure
- 2/5 active treatment group secondary success (40%)
- 1/5 initially in control group had no relief with secondary procedure
- 4/5 initially in control group had secondary success

5.1.2 Authors’ conclusions

- “PRFN provided lasting, complete relief, but only in a moderate proportion of patients … such relief can last for months to over a year, and if pain recurs the relief can usually be reinstated by repeating the procedure.”
- “Our results apply only to patients responsive to double-bind, placebo-controlled, diagnostic blocks whose treatment involves multiple lesions of the target nerves. The results cannot be generalized to apply to patients whose pain is confirmed by less stringent criteria or who are treated with less exacting variants of the technique.”

5.1.3 BCOHTA appraisal

This study has no major and few minor flaws as performed. However, several concerns are noted:

- The benefits of randomization decrease with sample size. A sample size of 12 in each group makes equal distribution of confounding factors less likely.
- A sample size of 24 also provides limited data on serious adverse events of this operative procedure.
- The sample size was sufficient to test the primary hypothesis of PRFN efficacy versus placebo. Additional patients were not justified because of the ethics of invasive sham procedures.
• The authors did not test blinding to determine patients, or the surgeon’s ability to estimate patient allocation beyond chance. This is particularly relevant, noting the presence of cutaneous anaesthesia in five treatment patients, and the powerful placebo effect demonstrated in the control group.

• Although not reiterated directly by the authors, the results of this study also do not apply to patients with C2-C3 z-joint lesions (50% of the referral patient population who undergo diagnostic anaesthetic nerve blockade).

• The authors did not report whether the rate or duration of success was associated with pre-operative pain intensity.

• 17/24 (9/12 Tx) patients had unilateral, single level z-joint pain resolved with anaesthesia. The question arises whether this is representative of a referral population.

• Internal validity is dependent on including patients in a referral population, who have suffered whiplash injury from motor vehicle accidents and have long duration of pain since the time of injury. Patient selection bias also occurs through the diagnostic screening procedure.

5.2 WALLIS et al (1997)\textsuperscript{35}

Wallis et al’s report\textsuperscript{35} is summarized for completeness. The study is explicitly based on the Lord et al\textsuperscript{28} study population. Wallis et al selected 17 of the 24 patients randomized to treatment and control, who did not have concurrent pain stemming from joints at other spinal levels. Wallis et al asked whether distress could be reduced following modulation of pain. They measured psychological distress before and after PRFN treatment, using a standard psychological questionnaire, the SCL-90-R. They report that six of the patients who received active treatment (67%) had no pain and no distress, one (11%) who received active treatment had pain but no distress, and three (38%) who received placebo had no pain and no distress. This study supports the conclusion that less pain is associated with less psychological distress.

Such a conclusion may appear banal, but evidence that pain causes distress remains important for patients whose cause of pain cannot be recognised in clinical encounters, while their distress clearly can. Doubts about the existence of underlying pathology or consequential pain can therefore be set against the measure of distress.
6  FINDINGS FROM PREVALENCE STUDIES OF CHRONIC, CERVICAL PAIN FOLLOWING INJURY

This first part of this section reports findings from a systematic search for epidemiological evidence regarding prevalence of chronic cervical pain following injury. These population-based prevalence studies primarily utilized two data sources:

i) automobile insurance records in British Columbia (BC), and other Canadian provinces; and
ii) cross-sectional and longitudinal surveys of neck-pain prevalence in geographic populations.

The following part of the section reports the prevalence of chronic cervical-pain patients among various clinical populations. These latter studies report on prevalence in cohorts of patients referred to pain clinics, seen in hospital emergency rooms, or followed in general practices. The studies identified are not based on a systematic review of published literature. A systematic review of clinical populations would include a very larger number of case series, and was considered beyond the scope of the present study.

The goal of this section is to provide the best evidence-based estimate of the number of people in BC who would potentially be referred to a PRFN treatment program. The potential health impact from such referral and treatment is estimated in section 7.

The preliminary screening of epidemiologic literature on whiplash identified 115 articles that were selected and retrieved for further review. These are listed in Bibliography II. After they had been reviewed, articles were categorized by the type of study and source of data.

6.1 Prevalence of PRFN-eligible patients in provincial insurance populations

The prevalence of whiplash injury is a function of both the incidence rate (injury events per year/total population) of whiplash injury, and the time-to-recovery.

A crude incidence rate for whiplash injury can be acquired relatively easily from automobile and Workers’ Compensation Board insurance claims records. The description ‘crude’ signifies that diagnosis of whiplash injury cannot be ruled either in or out using definitive diagnostic tests. Instead, whiplash injury is accounted when patients claim to have suffered this injury and the mechanism of injury logically fits with whiplash injury.
Time-to-recovery, the other determinant of the prevalence of a condition in a population, is far more difficult to estimate from insurance-claims data. Such data do not include actual recovery from injury. Instead, they report the time when a claim is closed, the client no longer receives compensation, a settlement is made, or services are no longer provided. The calendar date could reflect a variety of factors more impelling than the actual state of injury, such as the financial need of the injured person. Despite these limitations, several Canadian provinces have produced data on the incidence and prevalence of whiplash injury, including BC.

6.1.1 Incidence in provincial insurance populations

Table 5 summarizes the findings from the systematic search for population-based incident data. All three sets are from insurance records in Canadian provinces having single-payer auto-insurance. The data therefore includes all cases of whiplash compensated in each province.

Table 5  Whiplash incidence rates

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>Region</th>
<th>Rate / 100,000 / Yr</th>
<th>Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spitzer et al</td>
<td>1987</td>
<td>Quebec</td>
<td>70</td>
<td>SAAQ Insurance records</td>
</tr>
<tr>
<td>BCWI</td>
<td>1992+</td>
<td>BC</td>
<td>850</td>
<td>ICBC claims</td>
</tr>
<tr>
<td>Cassidy et al</td>
<td>1995</td>
<td>Saskatchewan</td>
<td>598</td>
<td>SGI claims (no fault)</td>
</tr>
<tr>
<td>Cassidy et al</td>
<td>1994</td>
<td>Saskatchewan</td>
<td>836</td>
<td>SGI claims (tort)</td>
</tr>
</tbody>
</table>

The Quebec Task Force found very few studies meeting its minimum inclusion criteria regarding any dimension of WAD. In particular, no population-based studies on the epidemiology of whiplash were found. In keeping with its mandate, the QTF commissioned the first population study, based in Quebec, using claims data from the Societe de l'assurance automobile du Quebec (SAAQ). The SAAQ data was published along with the comprehensive QTF report and supplement.

The QTF cohort included all 4,757 people who had sustained a whiplash injury in a motor vehicle accident in 1987 in Quebec and received some form of compensation from SAAQ. They excluded nine people who had filed claims in that year but received no compensation.
Initial incidence rates reported by the QTF included all 4,757 claimants in the cohort:

- 70 per 100,000 Quebec inhabitants
- 86 per 100,000 female Quebec inhabitants
- 54 per 100,000 male Quebec inhabitants
- 131 per 100,000 registered motor vehicles in Quebec

The rate found in Quebec and reported by the QTF is much lower than the rates in other provinces. This low rate has been noted in several publications critiquing the QTF methodology, analysis and conclusions. \(^1,6,38-42\)

The cohort was selected by identifying all individuals in the SAAQ database for 1987 who received compensation for a claim with an ICD-9 diagnostic code of 847.0. Because of the way the cohort was selected, an unknown number of individuals with whiplash were excluded for the following reasons:

1) individual did not seek treatment;
2) individual did not seek or was not eligible for compensation;
3) individual was injured in an employment setting (when expenses would be covered by a different insurer);
4) diagnosis was not classified as ICD-9 847.0; or
5) symptoms or time away from work did not last longer than one week (SAAQ does not compensate individuals who exhibit symptoms for less than one week). \(^39\)

The last mentioned item is likely to account for most exclusions from the Quebec cohort compared to other provinces. Individuals who were injured, but able to work, were not known to SAAQ, even if they received medical treatment for their condition. In the Saskatchewan study, 53.7\% (3977/7400) of claimants did not receive any income replacement because of their injury. \(^37 (p1182 – Table 1)\) A study based on data from the Swedish Road Traffic Injury Commission (responsible for determining level of compensation paid for traffic injuries) reported that 69\% of people suffering from whiplash did not receive work disability relief. \(^43\)

Besides having a much higher recovery rate and lower incidence rates, Quebec has a much smaller proportion of auto-insurance claims for whiplash injuries (Table 6). This is probably because the QTF cohort does not include patients who sought medical attention for their injury, but did not take time away from work for which they required compensation.
<table>
<thead>
<tr>
<th>Region</th>
<th>% of claims</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC</td>
<td>70%</td>
</tr>
<tr>
<td>BC</td>
<td>68%</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>78%</td>
</tr>
<tr>
<td>Quebec</td>
<td>20%</td>
</tr>
<tr>
<td>Sweden</td>
<td>28%</td>
</tr>
</tbody>
</table>

Cassidy et al\textsuperscript{37} provide annual whiplash incident data from Saskatchewan for 1994. During this time period, Saskatchewan had a tort system similar to BC, and single-payer insurance system for all drivers in the province. In Saskatchewan, the insurance provider is Saskatchewan Government Insurance (SGI). In the event of an automobile accident, medical and income-replacement benefits are paid by the SGI. “All practitioners must report to SGI information on patients seeking treatment for injuries sustained in motor vehicle collisions.”\textsuperscript{37 (p1180)} In BC, the Insurance Corporation of British Columbia (ICBC) covers the costs of medical and rehabilitation expenses, wage loss, and homemaker benefits.\textsuperscript{44} Clinicians in BC are required to report treatment provided to motor vehicle accident victims to ICBC (via the provincial medical services insurance billing plan).\textsuperscript{45}

Cassidy et al\textsuperscript{37} report a significantly decreased incidence of whiplash injury in 1995, after a change to a no-fault insurance system. The Cassidy study, similar to analyses of the QTC report on Quebec, shows the important influence that provincial health insurance and litigation policy have on formulating estimates of whiplash incidence.

ICBC has compiled a data warehouse which includes both incidence and time-to-recovery data, and has published data regarding the number of accidents and number of injuries. However, it provides no details as to definition of an injury, or how these injuries are categorized in relation to the QTF Whiplash Associated Disorder scale (Table 1). One incidence estimate often cited is based on figures quoted by the BC Whiplash Initiative, a multi-disciplinary educational strategy, mandated to implement the QTF findings. The BC Whiplash Initiative conducted an assessment of whiplash claims with ICBC, and estimated that since 1992, the incidence of whiplash has been approximately 850 cases per 100,000 population per year.\textsuperscript{36}
6.1.2  Time-to-recovery from provincial insurance records

Population-based research has not directly studied ‘time-to-recovery’. Instead, ‘time-to-claim-closure’ is the best proxy measure available. It provides, at best, a crude estimate of the actual time-to-recovery. The QTF, for example, reported that at 1 year, 97% of patients were ‘fully recovered’, that is, they no longer received compensation or income-replacement. However, they did not survey individuals to determine the degree of recovery at the time they returned to work or closed their claim. Table 7 shows estimates of time-to-recovery reported in different study samples.

Table 7  Reported time-to-recovery in insurance claim populations

<table>
<thead>
<tr>
<th>Source</th>
<th>Region</th>
<th>Sample</th>
<th>&lt; 1 Week</th>
<th>&lt; 1 Month</th>
<th>&lt; 3 Months</th>
<th>&lt; 6 Months</th>
<th>&lt; 1 Year</th>
<th>&lt; 2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cassidy et al33</td>
<td>Saskatchewan</td>
<td>insurance (tort)</td>
<td>8%</td>
<td>22%</td>
<td>35%</td>
<td>68%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cassidy et al33</td>
<td>Saskatchewan</td>
<td>insurance (no fault)</td>
<td>18%</td>
<td>54%</td>
<td>68%</td>
<td>88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spitzer et al2</td>
<td>Quebec</td>
<td>insurance</td>
<td>22%</td>
<td>53%</td>
<td>70%</td>
<td>98%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Similar to incidence-rates discussed above, there is wide variation in results, consequent on the research design, driving conditions, circumstances of the accident, the insurance/compensation system in the region, the means by which data was gathered, and the population from which the sample was selected.

The QTF provides the most detailed analysis and most complete reporting on time-to-claim-closure. It is to be emphasized, as discussed above, that whiplash incidence in the QTC cohort is about 10% of that found in BC and Saskatchewan, and is likely to represent more seriously injured individuals who received compensation for lost wages. Furthermore, the QTF only included people for whom a police report was filed, and who had no recurrence of symptoms.

The QTF reports that, of the 2,810 subjects in the inception cohort who had no recurrence of symptoms, 22.1% returned to usual activities or work within 1 week, 53% within 4 weeks, and 98.1% within 1 year. Of the 3,014 subjects, 6.8% (204) experienced a recurrence. However, if all 204 individuals who had a recurrence were symptomatic at one year, that would decrease the percentage recovered after one year from 98.1% to 90.5%. 2(p165)
Cassidy et al\textsuperscript{37} showed that recovery occurred twice as fast under no-fault insurance. As described above, Cassidy and colleagues compared the time-to-claim-closure in Saskatchewan under a tort system and a no-fault reimbursement system. They report a remarkable change in the length of time a claim was active: 54\% lower in the no-fault system (median = 433 vs. 194 days). Further assessment of this study population by Côté et al\textsuperscript{46} showed that under both the tort and no-fault systems there was an association between health state (pain, physical functioning, and depressive symptoms) and time-to-claim-closure. This finding suggests that the insurance system may be an important determinant for both claim closure and recovery.

Some authors term this insurance system phenomenon as ‘compensation neurosis’ or ‘litigation neurosis’. Proponents of this theory believe that “the persistence of pain and associated symptoms is related to an attempt by the injured party to garner financial compensation for injuries sustained … [C]ompensatable pain will be intractable despite therapeutic intervention and will resolve only after litigation has been settled.” \textsuperscript{47}

A more balanced interpretation might conclude that recovery from injury is dependant on a combination of bio-psychosocial factors, including compensation issues.

### 6.2 Prevalence of PRFN-eligible patients in provincial populations

Other potential sources of referrals for PRFN are people with chronic neck pain who may or may not have suffered whiplash injury. The only published population-based prevalence data, using a randomized sampling technique, is from Saskatchewan.\textsuperscript{48}

Côté et al\textsuperscript{48} classify neck pain in five Grades, including ‘0’ (Table 8). These Grades differ from those developed to classify WAD, by the QTF (Table 1- p.9 above). Côté et al refer to patient symptoms and function, whereas WAD refers to the type and degree of pathological injury.

In Saskatchewan during a 6-month period, 10.1\% in the adult population were noted at Grade II, and 4.6\% at Grade III or IV.
Table 8 Grading of whiplash (after Côté et al.\textsuperscript{48})

<table>
<thead>
<tr>
<th>Grade</th>
<th>Patient symptoms / function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>no pain / no disability</td>
</tr>
<tr>
<td>I</td>
<td>low pain intensity / low disability</td>
</tr>
<tr>
<td>II</td>
<td>high pain intensity / low disability</td>
</tr>
<tr>
<td>III</td>
<td>high pain intensity / moderately limiting</td>
</tr>
<tr>
<td>IV</td>
<td>high disability / severely limiting</td>
</tr>
</tbody>
</table>

At minimum, the 4.6\% of people with high pain intensity and disability could potentially be eligible for PRFN referral. However, the actual number is likely to be considerably smaller, owing to the inclusion of ineligible people in this category (for example, those suffering from chronic conditions such as arthritis or neurological conditions). In particular, there is no way of estimating whether the intense neck pain and disability is due to injury.

The study reports that 16\% of people had a lifetime history of neck injury in a traffic accident. However, the study does not report whether such accident occurred in the 6-month period concerning which the survey solicited a response.

One case-controlled study from Lithuania,\textsuperscript{49} often cited by proponents of compensation neurosis, is of questionable scientific validity. The authors used police records to identify victims of rear-end collisions in Lithuania. Two-hundred-and-forty accident victims and 202 matched controls were surveyed regarding their frequency and severity of head, neck, and back pain (82\% response rate). The mean follow-up time from the accident was 21.7 months (SD 4.9; 12-36). Neck pain was reported by 35.1\% of accident victims and 33.2\% of controls. The authors concluded that “chronic symptoms were not usually caused by the car accident.” The findings suffer from the methodological weakness inherent in this study design. The study is not representative, since few people in Lithuania have auto-insurance,\textsuperscript{49} which may limit the number of people who report collisions. The control may not be matched on several known and unknown factors influencing neck pain.
6.3 Prevalence estimates in various clinical populations

Several studies provide prevalence estimates in different clinical settings, including the Cervical Spine Pain Research Unit in Australia, general practices, and hospital emergency rooms. Each referral population differs in the degree to which it represents the general population of patients suffering whiplash injury. In addition, each population differs in the need for therapy and in rate of recovery. The various studies will therefore not be compared, but their findings used to estimate the proportion of whiplash patients found at various levels of a referral system.

Three studies were excluded from further analysis as they estimated incidence rates based on emergency or clinic samples, and did not report prevalence or time-to-recovery.

6.3.1 Research centre cohort

Three studies provide data on the prevalence of painful zygapophysial joints among patients referred to specialized pain clinics for investigation of their chronic cervical pain at the Cervical Spine Pain Unit in Newcastle, Australia. In all instances, these patients were referred to the cervical pain clinic for radiological and possibly anaesthetic investigation, not for evaluation as to their need for investigation. The latter would imply a less-severely afflicted population. As the authors report, “The patient’s pain was sufficiently disabling for the attending orthopedic surgeon, neurosurgeon, or physiatrist, to request invasive radiological investigation.”

The first study, Aprill et al, provides the methodologically-weakest estimate of prevalence. It is noted because it provides some of the only insights into the relationship between discogenic and z-joint induced pain sites in this type of clinical population.

Aprill and colleagues estimated symptomatic z-joints without use of randomized, alternate control injections. Pain needed to be present for at least 6 months, and not be attributable to myelopathy or radiculopathy. A z-joint was considered symptomatic if injection of contrast media into the joint exactly reproduced the patient’s pain, and if anaesthetizing the joint promptly relieved the patient’s pain for the duration of action of the local anaesthetic. The authors used the contrast media to confirm that in no case did the anaesthetic leak from the z-joint so as falsely to anaesthetize adjacent structures.
The authors report on 318 consecutive patients, 182 of which underwent ‘provocation discography’ alone. This procedure involves inserting a spinal needle into one or more discs and injecting normal saline to induce pain, and if clearly symptomatic, injecting local anaesthetic (1% lidocaine) to determine if the anaesthetic promptly and clearly eliminates the pain.

Patients were only considered for z-joint evaluation if “so requested by the referring physician or if it was considered to be indicated by the radiologist, provided that he was at liberty to do so according to the terms of the referral, and in accordance with the patient’s agreement to undergo and tolerate additional investigation. The indications included negative response to provocation discography at the same segmental level, persistent pain despite analgesic discography, tenderness over a zygapophysial joint, and pain in a region apparently unrelated to the level specified for primary investigation by the referring physician.”

Despite the very restrictive z-joint investigation criteria, 52 underwent z-joint investigation alone, and 76 underwent z-joint and discography. Overall, 53% of the sample had symptomatic discs, and 26% had symptomatic z-joints, either alone or in conjunction with symptomatic discs. The authors appropriately note that the prevalence of z-joint pain is likely to be substantially higher in other patient populations, because many patients having discography did not have z-joint assessments.

Two studies, Barnsley et al and Lord et al, examine the prevalence of z-joint pain in patient populations referred to the Newcastle Unit, following whiplash injury sustained in motor-vehicle accident. These are patients who have no signs or symptoms suggestive of nerve-root compression, and have no diagnostic features on plain radiographs of the neck.

The first study used comparative local anaesthetic blocks, and found a prevalence of cervical z-joint pain of 54% (95% CI 40-68%). This study examined 50 referred patients, all of whom defied conventional management and none of whom had neck pain prior to their motor-vehicle accident. The authors used double-blind, controlled comparison blocks on separate occasions with lidocaine or bupivocaine. All patients were seen by a rheumatologist and by a psychologist who administered pain questionnaires (McGill Pain Questionnaire and the Psychological Symptom Checklist SCL-90 Revised).

The second study, from the same authors, reports on a different consecutive series of patients seen at the same referral centre in Australia. The patient population is very similar to the population described above, but with prevalence determined by placebo-controlled anaesthetic blocks.
This study excluded all patients with C2-C3 z-joint pain, because the third occipital nerve, which innervates C2-C3, has a cutaneous branch, making blinded studies impossible. Patients with headache present were given occipital nerve anaesthetic blockade. If the procedure abolished the headache, then the investigation was terminated because the symptom was considered as arising from C2-C3 z-joint injury.

If the headache persisted, despite C2-C3 medial branch nerve anaesthetic blockade, then other levels received blockade with active and placebo injections, in accordance with the protocol. Each patient received either lidocaine 2% or bupivacaine 0.5% for the first block. If the patient received no relief from the first block, it was then repeated at an adjacent level until pain relief was obtained or all levels were injected. If pain relief was achieved, the patient returned for two further injections, at least one week apart. The prevalence of pain attributable to z-joint injury is shown in Figure 7.

Figure 7  Prevalence of pain arising from zygapophysial joints (Lord et al\textsuperscript{55} (p1740) )

A prevalence of C2-C3 z-joint pain of 50% (29%-71% CI) was found among patients with chronic neck pain and dominant headache after whiplash injury.

A prevalence of lower cervical z-joint pain of 49% was found among patients with predominant neck pain. In this case, patients needed only to identify the two different active agents used, but duration was not a diagnostic criterion. They had also to identify the placebo injection. This more sophisticated study confirms the earlier estimate of approximately 50%, using comparison anaesthetic agents.
In summary, approximately 50% of patients with predominant neck pain who are referred for investigation of z-joint injury were found to be diagnostic-test ‘positive’. Approximately 50% of patients with predominant headache will have C2-C3 z-joint injury. Approximately 50% of the patients with predominant headache who do not have C2-C3 injury will be diagnostic-test ‘positive’ (i.e. 25% of patients with predominant headache will have a positive diagnostic test for a level below C2-C3).

6.3.2 Primary care prevalence

No population-based studies report clinical referral patterns for chronic neck pain patients with or without injury. In particular, no data is available on which patients are referred to radiologists or pain clinics for invasive diagnostic tests or nerve ablative therapy. Moreover, no informal Canadian clinical referral patterns data could be located for this report.

One study provides an estimate of the prevalence of cervical z-joint pain among patients attending three independent rehabilitation physicians over a 3-year period. The patients were required to have cervical pain longer than 6 months which was unresponsive to conventional therapy. Z-joint pain was confirmed using two-stage medial branch anaesthetic blockade. The authors report that 36% of patients were confirmed to have pain arising from the z-joint. Although providing some insight into this general referral population, the retrospective chart review provides minimal insight into population prevalence.

The best estimate of a general practice cohort is found in studies by Radanov et al in Switzerland, which is similar to Canada in having universal accident insurance and nationwide health insurance. Radanov et al report findings from a prospective study of 117 individuals with whiplash referred by primary care physicians to participate in a prospective study in Switzerland. This study is noted here because, unlike most case series that passively receive patients, Radanov et al attempted to obtain a study population for a cross-section of clinical practices in their region. They solicited the referrals through letters to general practitioners, and announcements in the Swiss Medical Journal.

Radanov et al reported that their study sample was representative of the population of patients suffering whiplash injury in their referral area. Their assertion relies on comparison of the number of patients in their cohort to the number of injuries expected in their district using
population-based estimates. The authors did not report the actual number of whiplash injuries that occurred in their referral district, nor did they compare their cohort to the total whiplash injury population. The cohort included 17 patients with nerve-root irritation and paresthesia.

In their sample of 117 patients under the care of general practitioners, they report that at one year, 24% of patients still suffered from symptoms of whiplash, and 5% were disabled. A follow-up study of the same cohort at 2 years found 18% still had symptoms, and approximately 4% were considered disabled.

Although differences clearly exist between countries, this study provides detail on the intensity and duration of pain, and offers evidence to support an estimate that 4-5% of patients are disabled due to whiplash injury after 1 to 2 years.

Participation in this study depended on GP referral, which could potentially select people with more severe and intractable pain. However, in contrast to overly-inclusive insurance-claim data and the more-severely afflicted patients seen initially in the hospital setting, the cohort described by Radanov et al is more likely to reflect a broader spectrum of whiplash patients with chronic pain, with or without more severe initial injury leading to hospitalization.

6.3.3 Prevalence of PRFN-eligible patients among hospital cohorts

Three studies report recovery rates in cohorts identified through emergency departments (Table 9). Because these cohorts are hospital-based, they necessarily include people with the most serious neck injuries, both with and without multiple trauma. In addition, these cohorts likely underestimate the incidence of whiplash, because accident victims do not necessarily report to emergency rooms. For example, a survey of rear-end collision victims in Australia found that only 3.5% (3/86) people with whiplash had visited a hospital emergency department following their accident. Hopkin et al. compared police records with accident and emergency departments, and found that of people with a police record indicating they had whiplash injury, 45% did not report to an accident or emergency department in the region.

All three studies estimate the time to recovery by surveying whiplash patients at set intervals. These are summarized in Table 9, together with the recovery rates noted by Radanov et al from a cohort of primary-care patients.
Table 9  Recovery rates in clinical settings

<table>
<thead>
<tr>
<th>Source</th>
<th>Region</th>
<th>Sample</th>
<th>&lt; 1 Week</th>
<th>&lt; 1 Month</th>
<th>&lt; 3 Months</th>
<th>&lt; 6 Months</th>
<th>&lt; 1 Year</th>
<th>&lt; 2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partheni et al 59</td>
<td>Greece</td>
<td>Emergency dept.</td>
<td>91%</td>
<td>98%</td>
<td>99%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brison et al 60</td>
<td>Ontario</td>
<td>Emergency dept.</td>
<td>16%</td>
<td>39%</td>
<td>41%</td>
<td>44%</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>Deans et al 61</td>
<td>Ireland</td>
<td>Hospital</td>
<td>18%</td>
<td></td>
<td></td>
<td>57%</td>
<td>58%</td>
<td></td>
</tr>
<tr>
<td>Radanov et al 57-58</td>
<td>Switzerland</td>
<td>General practitioner</td>
<td>8%</td>
<td>62%</td>
<td>75%</td>
<td>81%</td>
<td>84%</td>
<td></td>
</tr>
</tbody>
</table>

Brison et al 60 conducted a study in Kingston, Ontario, a Canadian province with a no-fault insurance system. They surveyed all emergency department patients who had been in a rear-end motor-vehicle accident over a two-and-a-half-year period. The response rate was 87.9% (334/380). They found that at 1 year, 56% of people with whiplash associated disorders were still experiencing symptoms (including neck pain, upper back pain, or shoulder pain).

Partheni et al 59 surveyed 180 consecutive emergency patients over 36 months who reported neck pain following a motor-vehicle accident (36.6% rear impact). At 6 months, 100% of participants completed a survey, and only 1% reported experiencing neck pain. The original recruitment and follow-up was an investigation of neck pain, and not necessarily a diagnosis of whiplash. Subjects with previous neck injury or more severe whiplash associated disorders (Grade III and Grade IV from the QTF 2) were excluded.

Deans et al 61 surveyed 137 individuals one to two years after attending a hospital following a motor-vehicle accident (response rate of 137/175 = 78%). Forty-two per cent of those who reported neck pain had symptoms which persisted beyond one year.
7 HEALTH IMPACT ESTIMATE

The population health impact of PRFN depends on several key factors, some of which are estimated here. These include the prevalence of patients suitable for PRFN, PRFN referral rates, and the efficacy of PRFN in pain relief.

The most important factor, however, namely the long-term effectiveness of this procedure, cannot be estimated from available research data. PRFN is a palliative or temporizing technique that provides symptomatic relief. The long term need for that relief depends on the degree to which z-joint injury resolves. In the case of z-joint injury, as with many injuries to skeletal or cartilage tissue, it is entirely possible that no healing takes place. The literature examined offers no evidence that PRFN has any beneficial or adverse effects on healing.

7.1 Utilization estimate

Annual PRFN utilization would include a portion of the population suffering whiplash injury from a motor vehicle accident. Published ICBC data provides a population-based annual estimate of 850/100,000. This annual estimated rate of whiplash injury is supported by a published rate from Saskatchewan (836/100,000), a province with a similar government-funded, automobile insurance agency, and (at the time of the study) a tort-based legal claim system.

Applying this estimate to the BC population of approximately 4 million people results in a total of 34,000 whiplash injuries per year.

Only a small portion of this total whiplash-injury population would be eligible for PRFN referral. Duration of pain and severity of injury will be used to estimate the size of this subset.

7.1.1 Population-based estimate using pain duration and severity of injury

The subset of the population eligible for PRFN can be estimated from time-to-recovery data. In this case, the subset of interest are whiplash-injury patients with cervical pain symptoms persisting beyond twelve months from the time of injury.

It is noted that choosing the more limited subset of patients with pain beyond twelve months is inconsistent with the original broader focus for this health technology assessment report. The original research question included all patients with whiplash injuries persisting beyond 90 days.
Twelve months is used because almost all patients in the randomized controlled trial (Lord et al.)
and those enrolled in the PRFN diagnostic and treatment program at the Cervical Spine Research
Unit in Newcastle, Australia had had pain for a minimum of 12 months. It is noted that 3 months
was the minimum inclusion time. However, most patients described in most of the publications
from this Centre have suffered a minimum of 12 months of pain.

Using 12 months as the minimum duration since injury, a range for the number of eligible patients
can be estimated from the recovery rates reported by Cassidy et al for Saskatchewan and the QTF
report for Quebec. Cassidy, as a more inclusive cohort, forms the upper limit (65% recovered at 1
year). Cassidy et al include all people with and without police reports, and people who
are able to work but still have symptoms. In contrast, the Quebec Whiplash Cohort study which
included only patients who were compensated for work loss, forms the lower limit (97% recovered
at one year). The range of estimated eligible patients in BC is therefore as follows:

| Upper limit | 35% of 34,000 = 11,900 |
| Lower limit | 3% of 34,000 = 1,000 |

Severity of injury, pain, or disability are additional factors beyond time-to-recovery, which help to
determine what portion of the total population with whiplash injury might be eligible for PRFN
referral. PRFN referral is inappropriate unless pain or disability are quite significant. For
example, patients enrolled in the trial by Lord et al. scored 40-47 on a 100-point Visual Analogue
Scale; and scored 12-14 and 32-37 on the McGill Pain Questionnaire’s total word-count and pain-
rating, respectively. Both scores indicate moderately severe pain/disability.

The Quebec cohort, because it is restricted to more serious accidents and more serious injuries, is
more likely than the Saskatchewan study to provide a reasonable estimate of the number of patients
potentially eligible for PRFN referral. This adds some weight to using 3% (1000/year) to estimate
the number of whiplash injured patients potentially eligible for PRFN referral per year.

The 3% minimum figure from the QTC cohort is to some extent corroborated by data from the
Workers’ Compensation Board of British Columbia. The Compensation Board reports that, over
the past 5 years, approximately 5% of new whiplash claims, alone or in combination with other
injuries, are active for 6 months, and approximately 2% are active for 1 year. Most of these
injuries are due to motor vehicle accidents.
7.1.2 Clinical referral estimate

A population-based estimate of 3-5% of patients eligible for PRFN referral at one year is also corroborated by clinic-based estimates of injury duration and severity.

The best estimate of a general practice cohort is found in Radanov et al from Switzerland. In their sample of 117 patients under the care of general practice, they report that at one year, 24% of patients still suffered from symptoms of whiplash, and 4-5% were disabled.57

Although differences clearly exist between countries, this study provides some evidence to support that about 4-5% of patients are disabled due to whiplash injury after 1 to 2 years, and therefore may be eligible for PRFN referral.

7.1.3 Summary of PRFN referral estimate

A very crude estimate can be made for the purposes of the present health impact discussion. If the potential PRFN referral population is estimated at 3% of the total whiplash-injury population, together with an unknown number of people with chronic neck pain arising from other injuries, this would result in approximately 1000 patients per year in BC potentially referred to a cervical spine pain treatment centre for evaluation from automobile accidents. In addition, an unknown number of patients each year would be referred from other injuries, including those that are work-related.

7.2 Patient referral

Only a portion of patients eligible for referral will actually be referred to a chronic pain clinic. Referral will depend on several factors including: patient and physician interest in and awareness of PRFN; cost to the patient; and availability and location of the services.

At present, only two physicians in BC provide PRFN, one of whom is located in Vancouver, and one in Victoria. Access may be limited to people living near the major metropolitan centres in the south-west corner of the province.

Access to PRFN is further limited in Victoria because patients must pay privately for this service. As a result, the Victoria physician primarily conducts diagnostic assessments of chronic spinal pain, and associated headaches, using medial branch nerve blocks. These assessments and occasional PRFN procedures are paid for by third-party payers such as ICBC, or the Workers’ Compensation Board.
Access to the doctor in Vancouver is not limited by cost. He is paid a salary by a hospital for two
days a week to evaluate patients referred for suspected cervical z-joint facet pain.

Utilization is limited by the number of patients that can be seen. On each of the two days per week
that the physician evaluates patients with cervical spinal pain, he performs medial branch nerve
anaesthetic blocks on two new patients, and treats one patient with PRFN. PRFN treatment
requires an average of 2.5 to 3 hours. Assuming he works 40 weeks per year, a total of 160
diagnostic evaluations could be made. Each patient requires a minimum of 2 evaluations (one with
lidocaine and one bupivacaine), with 1 or 2 weeks between evaluations. A total of 80 patients
could be evaluated per year.

PRFN treatment could be provided to 40 cervical levels per year. Patients may require more than
one level, and more than one treatment at any given cervical level. Therefore, significantly fewer
than 40 patients per year could receive complete treatment of their cervical spinal pain.

If as few as 10% (100) of the estimated 1,000 people eligible for PRFN referral are actually
referred in BC, this would create a very substantial waiting list for this single Vancouver physician
providing services through the hospital-salaried funding mechanism.

Other physicians in BC provide other forms of PRFN treatment, or treatment with this form of
PRFN to other areas of the spine, such as the lumbar facets. However, they are described as having
substantial waiting lists of their own.

Recruiting additional treatment providers may or may not be possible, given uncertainty in funding
and potential difficulties of practice where patients are involved in litigation and/or insurance
claims. In this last-mentioned respect, insurance and compensation claims give rise to physician
concern, because of the substantial extra commitment of time and effort required if they are asked
to provide trial testimony.

7.3 Patient selection for PRFN treatment

A sizeable proportion of people referred to a cervical facet evaluation centre each year will be
found to have a positive diagnostic test using medial branch nerve anaesthetic blocks, and therefore
be eligible for PRFN. The proportion of patients suitable for PRFN in a referral population is best
estimated from published findings of the Cervical Spine Research Unit in Newcastle, Australia,
using the triple-block diagnostic test.
For 100 patients referred, 50 will have predominant neck pain and 50 will have predominant headache. Of the 50 with predominant neck pain, approximately 25 will have positive diagnostic tests. Of the 50 with predominant headache, approximately 25 will have C2-C3 injury. Of the 25 with injury below C2-C3, 50% (12) will have a positive diagnostic test.

The total of positive diagnostic tests is therefore estimated at 36 - 38 out of 100 (25 from patients presenting with predominant neck pain, and 12 from those presenting with predominant headache).

The diagnostic test, in this instance, involved the most methodologically-complex, triple-block, considered the ‘gold standard’ diagnostic test.55 (sections 3.4 & 6.3 above).

McDonald et al67 provides some observational evidence regarding the need for triple blocks. The authors found no difference either in terms of initial response rate or duration of pain relief between the 17 patients diagnosed with placebo-controlled blocks and the 11 patients diagnosed with comparative blocks, despite the evidence of a false-positive rate of 12% with the comparative blocks.

However, the small sample size may mask actual diagnostic test-performance differences which would become apparent with a larger sample. In this study, one person constitutes a 12% false-positive rate among 11 patients. It is important to note that patient selection parameters reflect strict double-blind conditions in all the double- and triple-block diagnostic procedures reported by McDonald et al, as well as in the other reports from the Cervical Spine Research Unit.

7.4 Initial pain relief: efficacy of therapy

Additionally, health impact depends on the proportion of PRFN patients who achieve relief of symptoms.

Based on Lord et al,28 approximately 70% of these patients electing to have neurotomy would have > 90 days free of pain. In the hypothetical example of 100 patients referred, 37 would be medial branch nerve anaesthetic-diagnosis positive for z-joint levels below C2-C3, and about 70% (26 patients, or 26% of the original referred cohort) would achieve this level of benefit. It should be recalled that the 70% efficacy estimate applies only to patients with z-joint levels below C2-C3.
The efficacy of therapy at the C2-C3 level was not considered adequate in a non-randomized trial to justify treatment at this level.\textsuperscript{65} However, more recent data (published in abstract form), reports that a modified PRFN technique, results in 70% success rate (complete relief of headache for at least 3 months).\textsuperscript{66} This level of health benefit also assumes strict patient selection under double-blind triple-block procedures and ‘senior’ operator skill.

### 7.5 Pain relief: duration and repeatability

Health impact is furthermore dependent on the duration and repeatability of the PRFN procedure.

McDonald \textit{et al.}\textsuperscript{67} provide evidence regarding duration of therapy and utility of repeat procedures. This observational study reports on 28 patients who had PRFN at a level between C3-C4 to C6-C7. All patients were seen from 1991-1996 at the Cervical Spine Research Unit, and had pain for greater than 12 months (median 69; inter-quartile range 50-106); 27/28 attributed their pain to motor-vehicle accidents. Diagnosis was made by comparative block in 11 patients, and by placebo-controlled block in 17 patients.

In 18/28 (64\%) of patients, initial pain relief lasted longer than 90 days. The duration of pain relief was defined as the period from treatment until the patient judged that pain had returned to 50\% of the pre-operative level.

“Of the 10 patients who failed to obtain relief after the first injection, 6 underwent repeat procedures. Only two of these patients obtained relief. Each of these patients underwent two successful procedures. In no case in which the initial procedure provided less than 30 days of pain relief was the repeat a success.”\textsuperscript{67 (p64)}

In 20/28 patients (71\%; 18 who initially benefitted, plus 2 who had successful repeat procedures), pain was relieved for > 90 days. Eleven out of 20 patients underwent repeat procedures when pain returned, all of whom had pain relieved for greater than 90 days (median duration of pain relief per procedure = 218 days; inter-quartile range 144-478).

The study by McDonald \textit{et al.} shows that repeat procedures are possible, and also that they are likely to be effective if the initial response lasted greater than 30 days. The study showed a wide range of initial and repeat responses, with both longer and shorter repeat response duration. Three patients had 3 procedures, 1 patient had 4, and 1 patient had 6.
Sapir and Gorup provide additional observational evidence regarding PRFN efficacy at controlling cervical pain associated with whiplash injury.\textsuperscript{68} Although reported as a comparison between patients ‘involved’ and ‘not-involved’ in litigation, Sapir and Garup provide additional evidence on pain relief. They report pain relief efficacy at one year, reported as change from baseline in a 10-point visual analogue pain-scale.

Their series consisted of 59 patients with cervical pain lasting at least 20 weeks following whiplash injury from an automobile accident. All patients underwent diagnostic blocks of the cervical medial branch nerves of the posterior ramus, using controlled, two-phase diagnostic method (see Macdonald et al above). Unlike Macdonald et al, where ‘complete or definite’ pain relief was required, a block was considered successful when a patient achieved an 80\% reduction in self-reported symptoms. Fifty patients were diagnostic-test positive and underwent PRFN.

Sapir and Gorup report a mean decrease of visual analogue scale of 4.6 (+/- 1.8) from baseline to one year. In addition, they report that 21 patients reported recurrence of pain within 1 year. Time to recurrence, defined as 50\% return of pain was 8.0 (+/- 2.0 months). They do not report on the frequency or efficacy of repeat procedures. Twenty-five patients did not have recurrence of cervical pain in one year. Based on this report, a conservative efficacy estimate is 50\%.

However, the long-term role of PRFN in relation to chronic neck-pain is unknown. For example, it is conceivable that patients may ultimately become PRFN-dependent, or may suffer either more or less severe pain, post-PRFN. Prolonged pain relief, through repeat procedures, can be anticipated in about 75\% of patients achieving initial benefit. Considering the hypothetical cohort of 100 referred patients, 37 of whom have PRFN treatment, approximately 20 will achieve prolonged pain relief through repeat procedures.

### 7.6 Health impact model

A model (Figure 8) was developed to illustrate each of the factors that contribute to the health impact of PRFN. Based on the foregoing, the diagram shows how an estimated 26 people per year would be expected to have ongoing relief from chronic whiplash pain. Given the number of variable factors and potential model weaknesses, however, this estimate is offered with considerable caution.
7.7 Limitations of health impact estimate

The health impact estimate provides, at best, a crude estimate of the number of patients who may be referred for PRFN assessment. The estimate is rudimentary because it requires as yet unconnected insurance and clinical data. The insurance agencies provide the most complete population samples, but the least accurate individual outcome data. In contrast, the clinical data sources provide more accurate individual patient condition, but with a biased population sample. Taken together, the number of patients eligible for PRFN seems greatly to exceed local resources. At the same time, it is not known whether local, or any other site outside the Cervical Spine Research Unit in Australia, can achieve the pain relief benefit reported by Lord et al.\textsuperscript{28}

Several other technical issues have a bearing on health impact assessment. Most notably, the randomized controlled trial estimates of benefit are based on the technical capability of one ‘senior’ individual working under extremely strict research conditions. The extent to which these results can be duplicated by others has not been rigorously established.

McDonald et al\textsuperscript{67 (p64)} report their observational findings in relation to different operators. The senior operator conducted 30 procedures, while the next most senior conducted 16. Two other operators conducted respectively 3 and 5 procedures in the course of training. The authors report that the senior and next most senior operator had no significant difference in duration of relief. They did not report the duration of relief for the operators in training. It must therefore remain largely unknown whether the extent of patient benefit achieved in the RCT is dependent on the unique skill of one technical operator.

“In principle, technical problems may affect the efficacy of the procedure. An inaccuracy of 1mm in electrode placement is sufficient for the target nerve to escape adequate coagulation.”\textsuperscript{67 (p65)}
Figure 8  Model of health impact of PRFN in BC

Population of BC  
4,000,000

850/100,000 have whiplash  
= 34,000

3% have chronic neck pain  
= 1,000

10% referred for block  
= 100

37% test (+) for C3-C5 z-joint pain  
= 37

70% > 90 days free of pain  
= 26

75% have repeat procedures  
= 20

97% recover in < 6 months  
= 33,000

90% not referred  
= 900

63 test (-)  
= 63

30% limited relief  
= 11

25% no repeat procedure  
= 6

Population without whiplash  
= 3,966,000
8 ECONOMIC IMPACT OF PRFN

The economic impact of PRFN is unknown, and remains impossible to estimate until much more is known about PRFN effectiveness, safety, and utilization. There are, for example, no published data on the impact of PRFN on the time to return to work, utilization of health care resources, or alternate therapy. Consequently, this section is limited to estimating the cost of performing a PRFN procedure. The cost estimate assumes that, following pain relief by diagnostic block, patients are believed to have z-joint pain.

The PRFN cost estimate given in Table 10 is based on Medical Services Plan fee items, hospital resource utilization, and time estimates for operators and technicians in a hospital providing PRFN in BC. Costs also reflect the procedure in BC, which is likely to differ in staffing and other requirements from protocols current elsewhere.

The estimate does not include the fee paid to the physician in this facility, either privately or through the provincial health insurance plan. Neither private or public fee rates have been established in the province. The physician is able to perform the procedure as part of his work as a salaried hospital radiologist.

Nor does the cost estimate include the cost of diagnostic blocks. Diagnostic blocks can be single (not controlled), double (controlled by different duration anaesthetics), or triple (placebo-controlled). Diagnostic blocks require separate hospital visits at separate times, but take only 10-15 minutes to perform, and need only fluoroscopy equipment and anaesthetic agents.

While more frequent diagnostic blocks increase the cost of investigations, they decrease the percentage of patients unnecessarily receiving PRFN (3.4.3 above). Where a single uncontrolled block is performed, approximately 46% of patients will be false-positive. With placebo-controlled block, this is reduced to 25% false-positive patients.31-33

A cost effectiveness analysis found that multiple controlled diagnostic blocks significantly reduces the overall costs of PRFN diagnosis and treatment, if the cost of PRFN exceeds the cost of diagnostic blocks by 4-8 times. That is, the increased number of less expensive diagnostic blocks is offset by decreasing the number of more costly PRFN procedures.69
Table 10 Estimated cost of performing a PRFN procedure *

<table>
<thead>
<tr>
<th>Procedural component</th>
<th>Estimated cost ($ CAN)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplies</strong></td>
<td></td>
</tr>
<tr>
<td>Femoral tray</td>
<td>10.00</td>
</tr>
<tr>
<td>Grounding pad</td>
<td>40.20</td>
</tr>
<tr>
<td>10cc syringe</td>
<td>0.05</td>
</tr>
<tr>
<td>25g needles</td>
<td>0.02</td>
</tr>
<tr>
<td>25g spinal needle</td>
<td>0.18</td>
</tr>
<tr>
<td>Kwik covers</td>
<td>6.30</td>
</tr>
<tr>
<td>Gloves</td>
<td>1.04</td>
</tr>
<tr>
<td>Sterile gowns</td>
<td>2.15</td>
</tr>
<tr>
<td><strong>Total Supplies</strong></td>
<td><strong>59.94</strong></td>
</tr>
<tr>
<td><strong>Staffing</strong></td>
<td></td>
</tr>
<tr>
<td>Medical radiation tech</td>
<td>106.20</td>
</tr>
<tr>
<td>Nurse</td>
<td>27.00</td>
</tr>
<tr>
<td>Aide</td>
<td>9.68</td>
</tr>
<tr>
<td>Clerical staff</td>
<td>11.41</td>
</tr>
<tr>
<td><strong>Total Staffing</strong></td>
<td><strong>154.29</strong></td>
</tr>
<tr>
<td><strong>Fees</strong></td>
<td></td>
</tr>
<tr>
<td>Professional fee</td>
<td>11.01</td>
</tr>
<tr>
<td>Procedural fee</td>
<td>175.95</td>
</tr>
<tr>
<td><strong>Total Fees</strong></td>
<td><strong>186.96</strong></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$ 401.19</strong></td>
</tr>
</tbody>
</table>

*NOTES*

1 Capital cost of equipment = $ 41,000
2 Hospital overhead costs (radiological equipment, operating room facilities etc.) not included
3 Staffing reflects use of regular staff in the cardiac angiography suite at this hospital
4 Professional fee is the fee paid to radiologists for reading x-ray images
5 Procedural fee is the general consultation fee paid to a radiologist
The cost of PRFN is minimal in comparison to the overall medical, legal, and social costs of whiplash. Whiplash-associated disorders result in very substantial costs to individuals, the health-care system, and society. Published ICBC data report that 70,000 accidents occur each year in the province, and 80,000 people suffer injuries. An ICBC representative reported that approximately 70% (56,000) of these people report a neck injury. ICBC estimates its annual costs for such injuries at approximately $500 million.

Côté et al report similar costs from SGI in Saskatchewan: “Between 1992 and 1994 ... whiplash accounted for 83% of all traffic injury claims made to SGI, and for 70% of all compensation costs.”

PRFN will benefit patients suffering the most costly whiplash associated disorders, those lasting longer than 6 months, which account for a disproportionally large percentage of the costs. The QTF, for example, provides an assessment of the percentage of total costs (compensation for time away from work, and health-care services not covered by the provincial health-care plan) at different time periods. For example, the percentage of total cost for those who had claims open 6 months or more was 46.0% (32.3 + 13.7%). (Table 11)

Table 11  
Assessment of percentage of total costs at different recovery periods (Quebec Task Force)

<table>
<thead>
<tr>
<th>Recovery time (months)</th>
<th>% of total claims</th>
<th>% of total costs</th>
<th>Cumulative total</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 2</td>
<td>61.5</td>
<td>15.5</td>
<td>15.5</td>
</tr>
<tr>
<td>2 – 6</td>
<td>26.0</td>
<td>38.5</td>
<td>54.0</td>
</tr>
<tr>
<td>6 – 12</td>
<td>10.6</td>
<td>32.3</td>
<td>86.3</td>
</tr>
<tr>
<td>≥ 12</td>
<td>1.9</td>
<td>13.7</td>
<td>100.0</td>
</tr>
</tbody>
</table>


9 DISCUSSION

Experimental or established therapy?

Funding policy requires categorization of PRFN treatment of chronic whiplash pain as either experimental or established. This question regarding the status of PRFN led ICBC to request the present health technology assessment project.

In Canada, established therapy usually becomes eligible for third-party funding, whether by government health insurance, an automobile insurance agency such as ICBC, or a Workers’ Compensation Board. Experimental therapies, by contrast, seldom receive third-party funding.

A standard continuum of developmental categories has been produced by the US National Institutes of Health: 71

- **Inception**: virtually untested
- **Innovation**: preliminary testing
- **Investigation**: confined to research protocols
- **Promising**: appropriate for some indications
- **Established**: adequately evaluated
- **Guidelines**: standard care

On the continuum from experimental to state-of-the-art, PRFN fits between the ‘investigational’ and ‘promising’ stages. The ‘investigational’ stage means “(t)here is insufficient evidence to determine the safety or effectiveness of the technology. Use of the technology in patient populations should be confined largely to research protocols.” 71 (p19) ‘Promising’ means the technology is proven effective in a randomized controlled trial.

PRFN meets several ‘promising’ criteria. The technology is not in a rapid state of evolution (remaining similar both within and between studies); it has been proven effective in a methodologically-sound RCT; and a clinical evaluation framework has been clearly established. This includes standardized methods for anatomical classification, a definition of procedural success, and reliable tools for clinical assessment, as well as necessary data collection forms. (It is unclear at this point whether there is a registry for operators to report PRFN complications.)
However, PRFN retains features of the ‘investigational’ category, primarily because efficacy and safety have only been established in a few carefully-selected individuals. In addition, the RCT demonstrated benefits exclusively by using the same senior operator for all diagnostic tests and treatment applications. The efficacy findings have been replicated in one observational study for operators not involved in the development and promotion of this technology. In the latter study, the efficacy at eliminating pain at 12 months is 50%, but these authors used less rigorous diagnostic methods and did not report on repeat procedures. In both studies, the researchers also report ongoing procedural problems because of the need for exceptional accuracy in locating the neurotomy probe.

Patient-selection criteria have not been standardized. In particular, the need for double-blind, triple-block procedure has not been accepted or adopted in many centres.

Moreover, the long-term safety, effectiveness, and durability of PRFN have not been established. People receiving PRFN may become dependent on this type of therapy at an unknown treatment interval. Similarly, a portion of the people receiving PRFN may achieve short-term relief (albeit for several months to a year) but may ultimately endure more years of pain if therapy results in rebound increased pain levels. Before being considered fully ‘promising’ therefore, PRFN evaluation requires, at minimum, long-term observational studies.

Long-term observational studies could serve the dual purpose of establishing the durability and safety of PRFN. In addition, it will facilitate measuring independent program performance against published efficacy standards.

Technical advancements may improve the rate and duration of success in diagnosis and care of patients with prolonged cervical pain following whiplash injury. Such advances are already providing data that suggest acceptable PRFN treatment efficacy for headache associated with C2-C3 z-joint injury.

Advances in the technology, however, cannot answer questions regarding the relative benefits of alternative invasive or non-invasive programs, versus PRFN. Other, non-invasive interventions for whiplash-associated disorder remain unproven through adequately controlled trials.

Consequently, while PRFN has become relevant in the insurance contexts because of its promise, uncertain clinical medical status means that insurance programs remain unsure how to handle reimbursement requests. Until this uncertainty is better resolved through further study, it is not possible to evaluate what insurance impact is likely to emerge.
Nevertheless, despite the limitations of evidence for categorization of PRFN along a continuum from inception to routine practice, in contrast to virtually every other treatment for chronic pain following whiplash, PRFN has been studied in a double-blind, randomized controlled trial and found effective versus placebo at reducing chronic neck pain.\textsuperscript{28} At minimum, the efficacy evidence from the randomized controlled trial has established the z-joint as a clinically-important anatomical structure in whiplash injury. In addition, the publication of a randomized controlled trial of PRFN has set a higher standard for outcome research in this area of clinical care.

More generally, double-blind controlled anaesthetic blocks will in all probability legitimate whiplash injury as clinical entity. For a number of authors, whiplash symptoms persisting beyond 6 weeks have been considered less attributable to unresolved injury, and more to the anxiety for an insurance settlement or other psychosocial factors.\textsuperscript{49,72-73} The valid efficacy evidence now available may help clinicians see whiplash injury as a legitimate condition, one which can result in long-term pain and disability in some individuals.\textsuperscript{74-76}

Since, however, the trial is a small trial of 24 carefully-selected patients conducted by the developers of the technique, their results require independent confirmation. To date, the efficacy in reducing chronic whiplash pain versus placebo has only been shown in a very carefully selected subset of patients diagnosed and treated at the Cervical Spine Research Unit in Newcastle, Australia. It should be clearly understood that the results achieved in a clinical trial in a specialist research centre do not predict the ability to obtain comparable results in clinical settings in BC.

At least one physician practising in BC has gained technical expertise from the Newcastle centre, and his institution has acquired recommended PRFN equipment. He determines patient eligibility and provides the PRFN treatment on patients referred from a chronic-pain clinic which excludes patients involved in litigation.

Clinical demand for PRFN already exceeds supply and continues to grow. This is because, in contrast to the categorical needs of the insurance industry, clinical care deals with innovations such as PRFN on a case-by-case basis. Regardless of insurance funding-decisions, a combination of the dire need of individuals with exhausted alternatives, referral opportunity, and the attainment of pain relief will in all likelihood continue to drive utilization.
10 CONCLUSIONS

- PRFN has been shown effective versus placebo in one RCT involving 24 very carefully selected patients with chronic neck pain following whiplash injury. This research establishes a higher standard for outcome research in the area of chronic cervical pain management. The burden of proof now rests with alternate treatment programs to show benefits using similarly strong study designs.

- The Cervical Spine Research Unit in Newcastle, Australia demonstrates excellence in its PRFN treatment program and its scientific research. The excellence of the program, however, paradoxically raises concerns about the replicability of treatment benefit outside this unique setting.

- PRFN diffusion is at a critical stage in British Columbia. Under ideal conditions, with rigorously applied selection criteria, and at the hands of expert operators, the efficacy of the procedure has been demonstrated. But these promising clinical findings do not provide evidence of the effectiveness of this procedure, at the hands of others, or when applied to the wider community and outside research settings.

- Given the concerns, rapid diffusion of this technology would be inappropriate. On the other hand, to limit the technology unnecessarily would restrict proven pain relief efficacy for certain individuals. A balance is needed, in which training and resource allocation may properly proceed, but conditional on outcome research and practitioner accreditation.

- Outcome research is required to determine benefit, harm, and cost in a particular setting, such as the province of British Columbia.
APPENDIX A: BCOHTA prioritizing criteria and PRFN

<table>
<thead>
<tr>
<th>BCOHTA criterion</th>
<th>Extent to which criterion met</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Number of users</td>
<td>Potentially large number of chronic whiplash injury patients in the province</td>
</tr>
<tr>
<td>2. Potential change in health outcomes</td>
<td>Potential treatment for intractable neck pain</td>
</tr>
<tr>
<td>3. Acquisition and operating costs to the health-care system</td>
<td>Costs in equipment and resources potentially significant</td>
</tr>
<tr>
<td>4. Potential to influence provider and consumer behaviour as a result of a review</td>
<td>Clarification of state of knowledge and diffusion</td>
</tr>
</tbody>
</table>
APPENDIX B: Search strategy

## I. CONVENTIONAL SEARCH

Computerised bibliographic databases searched included MEDLINE, HealthSTAR, EMBASE, and Current Contents. Example subject headings below were used in MEDLINE and HealthSTAR. The equivalent database-specific subject headings were used in EMBASE. Text words only were used in Current Contents, as no subject headings are applied in this database.

### Medical Subject Headings (MeSH) and textwords (keywords) used to identify neurotomy studies:


**Textwords:** “neck or cervical” and “injur* or trauma*”; “whiplash*”; “neck or cervical” and “hyperflexion or extension or acceleration or deceleration”; “zygaphyseal”; “neurotomy”; “denervation”; “z-joint”; “radiofrequency or radio-frequency” and “neurotomy or rhizoly* or cauter* or denatur* or lesioning or thermocoagulat*”; “epidemiolog*”; “population-based”; “prevalence”; “incidence”; “natural history,” and “population research”.

### Medical Subject Headings (MeSH), document types and textwords (keywords) used to identify randomized controlled trials and controlled trials:


**Document types:** “Randomized Controlled Trial”; “Clinical Trial”; Clinical Trial, Phase I”; “Clinical Trial, Phase II”; “Clinical Trial, Phase III”; “Clinical Trial, Phase IV”; “Controlled Clinical Trial”; “Meta-analysis” and “Multicenter Study”.

**Textwords:** “random* or control* or clinical” “trial*”; “single or double or treble or triple or dummy or shani” and “blind* or mask”; “placebo*”; “meta-analys*”; “metaanalysis*”; “random* alloc*”; “parallel group*”; “crossover or cross-over” “study or studies or trial*”; “latin or grecolatin or greco-latin” “square*”; “incomplete block*”; “intensive or factorial or sequential” “design*”; “matched pair*”; “technolog* and assess*”; “datta”; “diagnostic therapeutic technology”; “evidence-based”; “expert panel*”; “systematic review*”; “critical” “appraisal* or review*”; “cochrane “collaboration or collaborative”; “prospective” “study or studies or trial*”; “multivariate analys*”; “risk factor*”; “odds ratio*”; “evaluation” “study or studies or trial*”; “comparison group design”; “historical cohort*”; “comparative or sampling or multicent* or multi-cent*” “study or studies or trial”; “program* or programme*” “evaluat*”; “case control”, and “research” design*”.

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### II. FUGITIVE SEARCH

<table>
<thead>
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<th>1. In-House Database Searched</th>
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<td>• Medweb Public Health</td>
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<table>
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<th>6. Internet Search Engines</th>
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<td>• Google</td>
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<td>• LexBot</td>
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<td>• LexBot</td>
<td>• Adobe Acrobat PDF Search</td>
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<table>
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<th>3. Commercial Database Searched</th>
<th>7. Organizations Contacted</th>
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<tr>
<td>• Cochrane Library</td>
<td>• Agence d'Evaluation des Technologies et des Modes d'Intervention en Santé (AÉTMIS)</td>
</tr>
<tr>
<td>• CRISP (Computer Retrieval of Information on Scientific Projects)</td>
<td>• Alberta Centre for Injury Control and Research</td>
</tr>
<tr>
<td>• Dissertation Abstracts</td>
<td>• American Academy of Neurology</td>
</tr>
<tr>
<td>• FindArticle.com</td>
<td>• American Society of Neuroradiology</td>
</tr>
<tr>
<td>• GrayLit Network</td>
<td>• Association of Pain Management Anesthesiologists</td>
</tr>
<tr>
<td>• HSRProj (NLM)</td>
<td>• Department of Functional Anatomy, Utrecht University, The Netherlands</td>
</tr>
<tr>
<td>• HTA Database</td>
<td>• Department of Rheumatology, Concord Hospital, New South Wales</td>
</tr>
<tr>
<td>• National Research Register</td>
<td>• Division of Workers' Compensation, State of Colorado</td>
</tr>
<tr>
<td>• PAIS</td>
<td>• Institute for Health and Outcomes Research, University of Saskatchewan</td>
</tr>
<tr>
<td>• Papers1st (OCLC) – conferences &amp; paper abstracts</td>
<td>• Insurance Corporation of British Columbia</td>
</tr>
<tr>
<td>• REHABD</td>
<td>• International Spinal Injection Association</td>
</tr>
<tr>
<td>• TRIP database</td>
<td>• Newcastle Bone and Joint Institute, University of Newcastle, Australia</td>
</tr>
<tr>
<td>• CAM on PubMed</td>
<td>• Physical Medicine Research Foundation</td>
</tr>
<tr>
<td>• Web of Science</td>
<td>• Radiological Society of North America</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>• UBC Library Catalog</td>
<td>References of retrieved articles were reviewed to identify further relevant citations.</td>
</tr>
<tr>
<td>• BC Ministry of Health Library Catalog</td>
<td></td>
</tr>
<tr>
<td>• CHID Online (Combined Health Information Database)</td>
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</tr>
<tr>
<td>• CISTI Library Catalog</td>
<td></td>
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<tr>
<td>• WorldCat</td>
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<tr>
<td>• NLM Locator Plus</td>
<td></td>
</tr>
</tbody>
</table>

8. Reference Scanning

References of retrieved articles were reviewed to identify further relevant citations.
III. EPIDEMIOLOGY OF WHIPLASH

CONVENTIONAL SEARCH

Computerised bibliographic databases searched included MEDLINE, HealthSTAR, EMBASE, and Current Contents. Example subject headings below were used in MEDLINE and HealthSTAR. The equivalent database-specific subject headings were used in EMBASE. Text words only were used in Current Contents, as no subject headings are applied in this database.

Medical Subject Headings (MeSH) and textwords (keywords) used to identify neurotomy studies:

**MeSH:** “Explode Neck Injuries”; “Explode Cervical Vertebrae”; “Explode Wounds, Penetrating”; and “Explode Motor Vehicle”.

**Textwords:** “neck or cervical” and “injur* or trauma*”; “whiplash*”; “neck or cervical” and “hyperflexion or extension or acceleration or deceleration”; “motor vehicle*”; “automobile*”; and “motor cycle*”.

Medical Subject Headings (MeSH), document types and textwords (keywords) used to identify epidemiological studies:

**MeSH:** Explode “Epidemiology”; “Prevalence”; “Incidence”; “Natural History”; and “ep [subheading]”.

**Textwords:** “epidemiolog*”; “population-based”; “prevalence”; “incidence”; “natural history”; and “population research”.

---

Percutaneous radio-frequency neurotomy in chronic pain from whiplash injury
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## APPENDIX C: BCOHTA intervention study appraisal form

### INTERVENTION STUDY APPRAISAL FORM

<table>
<thead>
<tr>
<th>Reference</th>
<th>Assessment</th>
<th>WHY?</th>
<th>HOW?</th>
<th>WHO?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ Excellent □ Good □ Fair □ Poor</td>
<td>□ Is sufficient evidence presented to justify the study?</td>
<td>□ controlled trial</td>
<td>□ Is the population from which the sample is drawn CLEARLY described?</td>
</tr>
<tr>
<td></td>
<td>□ Is there a CLEAR statement of the purpose of the study</td>
<td>□ prospective analytic study □ retrospective analytic study</td>
<td>□ Are inclusion and exclusion criteria specified and replicable?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Is there a CLEAR statement of the study hypothesis?</td>
<td>□ before-after study □ cross-sectional study</td>
<td>□ Do the inclusion and exclusion criteria match the goals of the study?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>□ Is it clearly outlined whether the study is considering: EFFICACY or EFFECTIVENESS?</td>
<td>□ case series</td>
<td>□ Do the authors account for every patient who is eligible for the study but does NOT enter it?</td>
<td></td>
</tr>
</tbody>
</table>

### COMMENTS

- □ If it is a controlled trial, is the allocation of subjects TRULY randomized?
- □ Is the baseline comparability of the treatment and control groups documented?

### BLINDNESS

- □ unblinded □ double-blind
- □ single-blind □ triple-blind
- □ Was prognostic stratification used?

### COMMENTS
<table>
<thead>
<tr>
<th>WHAT?</th>
<th>HOW MANY?</th>
<th>SO WHAT?</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the intervention?</td>
<td>☐ Was statistical significance considered?</td>
<td>☐ If differences were detected, were they clinically significant?</td>
</tr>
<tr>
<td>☐ Is it clearly defined and replicable?</td>
<td>☐ Were statistical tests applied appropriately?</td>
<td>☐ Were the patients entered and analyzed in the study sufficiently representative that the results can be generalized to other patients?</td>
</tr>
<tr>
<td>☐ Was compliance with intervention(s) measured and non-compliers analyzed correctly?</td>
<td>☐ How many tests of hypothesis (p-value) appear in the article?</td>
<td>☐ Was the intervention as performed by those in the study sufficiently representative that the results may be generalized to other settings?</td>
</tr>
<tr>
<td>☐ Were contamination and co-intervention considered?</td>
<td>☐ Did the authors consider sample size requirements prior to the study?</td>
<td>☐ Were the outcomes assessed in the study sufficient to guarantee which of the therapies under study does the greatest good?</td>
</tr>
<tr>
<td>☐ Were all patients who entered the study accounted for?</td>
<td>☐ When no differences were found, was there any consideration of possible β-error?</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>☐ Were withdrawals, drop-outs, cross-overs, and poor compliers analyzed in accordance with the aims of the study?</td>
<td>☐ Was the study large enough to detect important differences?</td>
<td>COMMENTS</td>
</tr>
<tr>
<td>☐ What outcome measures were utilized? Were all the relevant outcomes reported?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COMMENTS</td>
<td>COMMENTS</td>
<td></td>
</tr>
</tbody>
</table>
## APPENDIX D: Observational studies (case series)

<table>
<thead>
<tr>
<th>Study</th>
<th>Condition &amp; mean duration</th>
<th>Diagnosis method</th>
<th>Technique</th>
<th>Number</th>
<th>Pain outcome</th>
<th>Follow-up duration (mean mths.)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schaerer (1978) 10</td>
<td>cervical and lumbar; 24 mths.</td>
<td>facet block</td>
<td>PRFN, 70 C, 2 min.</td>
<td>46</td>
<td>2/4 excellent or good</td>
<td>13</td>
<td>only immediate follow-up reported</td>
</tr>
<tr>
<td>Schaerer (1980) 17</td>
<td>headache with neck pain; 33 mths.</td>
<td>single facet block</td>
<td>PRFN, 70 C, 2 min.</td>
<td>81</td>
<td>19/24 excellent or good</td>
<td>20</td>
<td>only immediate follow-up reported</td>
</tr>
<tr>
<td>Sluijter &amp; Koetsveld-Baart (1980) 28</td>
<td>unblinded, single facet block</td>
<td>PRFN, 80 C, 60 sec. posterior primary ramus</td>
<td>100</td>
<td>78/100 good</td>
<td>16-31</td>
<td>few outcome details</td>
<td></td>
</tr>
<tr>
<td>Sluijter &amp; Mehta (1981) 8</td>
<td>z-joint pain</td>
<td>single block of z-joint or dorsal rami</td>
<td>PRFN</td>
<td>35</td>
<td>13/35 entire or significant relief</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Hildebrandt &amp; Argyakis (1986) 29</td>
<td>neck pain; 2 mths.-20 yrs.</td>
<td>facet block</td>
<td>not described</td>
<td>466</td>
<td>356 injury</td>
<td>2-121</td>
<td>inadequate study report</td>
</tr>
<tr>
<td>Vervest &amp; Stolker (1991) 81</td>
<td>Headache and neck pain; 2-20yrs.</td>
<td>clinical, no blocks</td>
<td>PRFN, 67 C, 90 secs.</td>
<td>53</td>
<td>44/53 good or excellent</td>
<td>18</td>
<td>6/53 post op pain, 1/53 neuritis</td>
</tr>
<tr>
<td>van Suijlekom et al (1998) 29</td>
<td>cervicogenic headache, 6-&gt;60 mths.</td>
<td>clinical</td>
<td>PRFN, 60 sec.</td>
<td>15</td>
<td>12/15 complete or good (at 8 wks.)</td>
<td>2, 8, and 16</td>
<td>showed decreased analgesic use, fewer days/week with headache</td>
</tr>
<tr>
<td>McDonald et al (1999) 82</td>
<td>neck pain &gt;12 mths.</td>
<td>random, double-blind, dual and triple anaesthetic blocks</td>
<td>PRFN, 80 C, 90 secs. matrix of lesions</td>
<td>28</td>
<td>18/28 pain relief &gt; 90 days (mean 218 days)</td>
<td>3, and 12</td>
<td>repeat 11/20 successes</td>
</tr>
</tbody>
</table>
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BC Office of Health Technology Assessment


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