

# A Review of the Literature on Whiplash Associated Disorders

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## PREFACE

RAND Europe was asked by the Swiss Insurance Association (SIA) to study what treatment strategies are appropriate in dealing with whiplash associated disorders (WAD), with a specific focus on prevention of long-term disability. The main objectives of the study are:

1. Identification of factors related to the event that triggered whiplash as well as to the person that suffers from a whiplash which are conducive to chronic WAD.
2. Determination of what treatments are considered appropriate in specific cases as defined by the conjunction of the identified factors.

These objectives are achieved by the conduct of three linked tasks:

1. A statistical analysis of whiplash insurance cases.
2. A review of the existing literature on whiplash (focusing on prognosis and treatment).
3. An expert panel to gain an insight in clinical expertise on WAD.

The present document contains the results of the literature review on WAD. It focuses on prognostic factors for WAD and on the appropriateness of different treatment strategies. In addition, it briefly discusses diagnostic methods and epidemiological information on the prevalence of WAD.

The basis for this literature review is a literature review done by the Quebec Task Force (QTF) which includes articles on WAD published between January 1980 and September 1993. The present literature review summarizes the relevant parts of the QTF-review, and adds articles that have been published since then (i.e. articles published between October 1993 and March 2001). The literature review mainly serves as an input to the expert panel, but can also be read as a separate document.

It needs to be stressed that this review is not a systematic review including only research of the highest scientific quality. Since research of the highest quality is not available in all areas relevant to our research, we also included articles that contain relevant information, but are of lesser quality. We therefore took a somewhat pragmatic approach to the literature review.

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## LIST OF ABBREVIATIONS

CI =	Confidence Interval
ICD-10 =	International Classification of Diseases-10
MCMI-I =	Million Clinical Multiaxial Inventory-I
MEP =	Motor Evoked Potential
MRI =	Magnetic Resonance Imaging
MVC =	Motor Vehicle Collision
NSAIDs =	Non Steroid Anti-Inflammatory Drugs
PASAT =	Paced Auditory Serial Addition Test
PEMT =	Pulsed Electromagnetic Treatment
POMS =	Profile of Mood States
QTF =	Quebec Task Force
RCT =	Randomised Clinical Trial
ROM =	Range of Motion
SCL-90-R =	Symptom Checklist-90-Revised
TENS =	Transcutaneous Electrical Nerve Stimulation
VAS =	Visual Analogue Scale
WAD =	Whiplash Associated Disorders
z-joint =	Zygopophyseal joint

## 1. INTRODUCTION

### 1.1. BACKGROUND OF THE LITERATURE REVIEW

Whiplash is a frequently occurring result of automobile collisions, but continues, despite the best efforts of medical science, to be ill understood. Definitive diagnosis purely based on physical evidence is not possible, the course of the condition is not well understood, and it is unclear what the most appropriate treatments for whiplash associated disorders (WAD) are. RAND Europe was asked by the *Schweizerische Versicherungsverband* (Swiss Insurance Council) to study what treatment strategies are appropriate in dealing with whiplash associated disorders (WAD), with a specific focus on prevention of long-term disability. The main objectives of the study are:

1. Identification of factors related to the event that triggered whiplash as well as to the person that suffers from a whiplash which are conducive to chronic WAD.
2. Determination of what treatments are considered appropriate in specific cases as defined by the conjunction of the identified factors.

These objectives are achieved by the conduct of three linked tasks:

1. A statistical analysis of whiplash insurance cases.
2. A review of the existing literature on whiplash (focusing on prognosis and treatment).
3. An expert panel to gain an insight in clinical expertise on WAD.

The present document contains the results of the literature review on WAD. The literature review gives an overview of what we currently know about WAD. It briefly focuses on diagnosis and prevalence of WAD. The basis for this literature review is a literature review done by the Quebec Task Force (QTF) which includes articles on WAD published between January 1980 and September 1993. We will use the review of the QTF as a basis for our own work. We will distinguish between the conclusions of the QTF, and studies that were published after the QTF finished its work.

### 1.2. DEFINITION OF WHIPLASH IN THIS LITERATURE REVIEW

The QTF already concluded that "one of the difficulties in evaluating the literature concerning the type of injury commonly designated as whiplash is the fact that the term 'whiplash' is used variously to describe a mechanism of injury, the injury itself, the various clinical manifestations consequent to the injury, and constellations of signs and symptoms designated as 'whiplash syndrome'". The definition of whiplash adopted by the QTF is:

*Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck which may result from rear-end or side impact, predominantly in motor vehicle collisions, but also from diving accidents and other mishaps. The energy transfer may result in bony or soft tissue injuries (whiplash injury) which in turn may lead to a wide variety of clinical manifestations (whiplash associated disorders). The term whiplash associated disorders is thus used to describe the clinical entities associated with the energy transfer and the injury.*

Since our literature review is a follow-up to the review of the QTF and we have no reason to deviate from the definition of whiplash as defined by the QTF, we will use the terms 'whiplash' and 'whiplash associated disorders' as defined above. When whiplash associated disorders are present longer than 6 months, they are considered to be chronic.

Chronic whiplash associated disorders may be conceived as a variant of somatoform disorder (ICD-10 F45.9). Other variants are, for example, chronic back pain and chronic fatigue syndrome. Somatoform disorders are disorders in which patients have physical symptoms (e.g. pain, light-headedness) that suggest a general medical condition, but are not fully explained by a general

medical condition. These symptoms are often troubling enough to disturb social and occupational functioning. Although the literature on somatoform disorders might contain useful information on WAD, in this literature review we exclusively focused on WAD-specific literature<sup>1</sup>.

### **1.3. SET-UP OF THE LITERATURE REVIEW**

Chapter 2 focuses on the research methodology of the literature review. It describes the inclusion criteria, the search strategy, and the quality of the articles found. Chapter 3 briefly describes the appropriateness of methods used to diagnose WAD, and discusses articles focusing on the prevalence of WAD. Chapter 4 discusses the factors that are associated with the development of long-term whiplash complaints. It focuses on signs and symptoms, radiological findings, socio-demographic and economic factors, psychological factors, and crash-related factors. Appendix A contains a table in which this information is summarized. Finally, chapter 5 summarizes articles focused on the appropriateness of specific treatment strategies for whiplash patients. Appendix B contains a table in which this information is summarized.

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<sup>1</sup> In this respect, we also excluded from our definition and examination WADs that include mild brain injury (MBI). There is still much debate about whether MBI can be part of WADs or whether it is a separate syndrome that need to be considered by itself.

## **2. MATERIAL AND METHODS**

### **2.1. INCLUSION CRITERIA**

The literature review focuses on WAD, i.e. clinical manifestations of an acceleration-deceleration injury of the neck, resulting from motor vehicle accidents. It focuses on both acute and chronic manifestations of WAD. To be included in our literature review, articles had to meet the following criteria:

- Studies published in the period October 1993 - March 2001 (The QTF retrieved articles published in the period January 1980 - September 1993. We therefore focused our literature search on the period between October 1993 and March 2001).
- Studies focusing on adults;
- Studies in English, French, German, and Dutch;
- Original articles (no comments, editorials, or reviews; single case reports and laboratory and simulation studies were also excluded);
- Studies that focus on diagnosis, symptoms, prognosis, and/or treatment of WAD.

It needs to be stressed that this review is not a systematic review including only research of the highest scientific quality. Since research of the highest quality is not available in all areas relevant to our research, we also included articles that contain relevant information, but are of lesser quality. We therefore took a somewhat pragmatic approach to the literature review.

Where possible, the selection of articles was made based on information from the abstracts. When abstracts were not available, we retrieved the full article in order to decide whether it met the inclusion criteria. We studied the full text of all articles that met the inclusion criteria.

### **2.2. DATABASE SEARCH**

The books and articles reviewed by RAND Europe came from a wide variety of sources. In addition to medical databases, we also searched other databases, because we were not only interested in medical aspects of WAD, but also in social and legal aspects. We searched the following databases for the terms 'whiplash' and 'neck injury, accidents':

- Medline
- Embase
- Dialog
- PsycInfo
- Legal Resource Index
- TRIS Online
- Books in Print
- Los Angeles County Law Library Catalog

Using the search terms, we identified approximately 500 articles on WAD. After screening 84 articles were included in this review [see bibliography]. For this study, we had to rely on the diagnostic assessment of doctors for the inclusion of patients in a study. We had to assume that for all included patients the diagnosis WAD was made correctly.

### **2.3. STRENGTH OF EVIDENCE**

The QTF concluded that "The body of evidence proved to be so heterogeneous in nature and quality, so unconventional in methodological approaches used by investigators, and so sparse after we screened out material clearly outside the scope of the Task Force, that the invocation of strict criteria of admissibility envisioned became unrealistic". Although the number of methodologically sound

studies has increased in recent years, we believe this statement is still true. In this literature review, we decided to admit several studies other than randomized clinical trials because no stronger evidence was available. Because of the low quality and the high diversity of articles found, we decided not to apply statistical pooling to the articles.

In this literature review we did not only include studies of the highest scientific quality, but also included some lower quality articles. The following pyramid briefly summarizes the generally accepted hierarchy of study designs (<<http://servers.medlib.hscbklyn.edu/ebm/2100.htm>>):



In our literature review, we included studies ranging from randomized controlled double blind studies to case series. Studies that are lower in the hierarchy did not meet the inclusion criteria. The summary tables in the appendices contain information on the types of studies described in this review. This might help you to get an impression of the quality of the included articles.

Finally, we also did not provide indications of the strength of evidence of the studies that are included in this review. Measures to determine strength of evidence are mostly derived from or oriented to Randomized Controlled Studies/Trials. On the whiplash issue, these type of studies are very limited. Using strength of evidence in this environment, would mean that most of these studies would be indicated to be of low quality, while the information that they provide can still be very valuable and help to improve knowledge of WADs. In addition, there is continuous discussion about what specific scale to use to determine strength of evidence.



### 3. DIAGNOSIS AND SYMPTOMS

This chapter gives a brief overview of articles that have been published on the appropriateness of methods used to diagnose whiplash, and gives a somewhat more extensive overview of articles focusing on the prevalence of whiplash associated disorders.

#### 3.1. DIAGNOSTIC TECHNIQUES

The QTF was unable to find any acceptable studies that permitted one single judgment with respect to the predictive value, sensitivity, specificity, and acceptability of diagnostic tests. Most of the articles focusing on diagnosis of WAD did not meet the inclusion criteria of the QTF. The accepted studies addressed: X-rays, MRI, measurement of cervical range of motion, strength, and neurobehavioral tests.

Since the review of the QTF, articles were published on 3D head kinematics, extension and coordination tests, MRIs, tomographies, bone scintigraphy, surface electromyography, and diagnostic z-joint blocks. However, these did not permit one single judgment with respect to the predictive value, sensitivity, specificity, and acceptability of diagnostic tests.

Although additional studies on diagnostic methods were published in recent years, we found that the available evidence is still very poor. This was confirmed by a literature review on diagnostics done by the Norwegian Centre for Health Technology Assessment (SMM, 5/2000) which concluded that "the majority of articles refer to patients groups plagued by selection bias and often without the use of control groups". Based on the existing studies it may be concluded that none of the above diagnostic tests have provided consistent findings, none currently can be recommended to confirm a diagnosis of WAD (Young, 2001).

#### 3.2. PREVALENCE OF SYMPTOMS

In this chapter, we will discuss the articles that are focusing on the symptoms and signs presented by whiplash patients after a motor vehicle collision. We will discuss articles that give an overview of multiple signs. In addition, some articles have appeared that focus on individual symptoms such as third occipital nerve headache, dizziness, ability to reproduce head position, saccadic eye movements, and vocalized complaints. These studies have not been included in the review. The following articles discuss multiple symptoms:

Di Stefano *et al.* (1995a) evaluated attentional functioning and memory of 117 whiplash patients during the first two years after experiencing injury. Two years following initial trauma, 21 patients remained symptomatic. Results show no impairment of memory in patients with complaints. In attentional functioning, patients with complaints showed more difficulty with tasks of divided attention than the control group. In another article in the same year Di Stefano *et al.* (1995b) concluded that no systematic differences in quantitative or qualitative aspects of learning or memory between the symptomatic and asymptomatic and between patients and normal controls were found.

Borchgrevink *et al.* (1996) did a retrospective study to map, among others, subjective feeling of health and quality of life among patients several years after the injury. Data from a questionnaire showed that of 345 persons, 201 (58%) reported to have chronic complaints (the follow-up period was more than 2.5 years) linked to the injury. Most of the patients reported more than one symptom. 77% reported neck stiffness; 72% reported headache; 69% reported neck pain; 39% reported dizziness; 19% reported nausea; 14% reported double vision; 7% reported concentration problems; and 1% reported buzzing in the ears. Of the patients with chronic symptoms, 55% reported being in very good or good health; 29% having average health, and 16% were in bad or very bad health. On

the question of quality of life, 39% were generally pleased with their life; 52% described it as 'only so and so', while 9% were displeased.

Hagström *et al.* (1996) examined 30 patients with whiplash injuries 1 to 55 months after the accidents. Pain had appeared on the day of the accident in 24 (80%) of the patients and with different delays in the remainder. The mean pain intensity was 43 mm (SD 26) on a visual analogue scale. All patients had pain in the neck, 17-33% had headache and 6-17% had pain in various regions of the arms. Thirteen patients (43%) suffered from constant pain. Muscle tenderness was higher at all tested sites compared with controls. The tolerance level to pressure pain in the index finger as well as grip strength and neck mobility was reduced compared with controls. The patients complained about poorer mental well-being compared with a reference group representing the general population and compared with a group of tension-type headache patients.

Mayou *et al.* (1996) interviewed 57 whiplash patients and described outcomes. At 1 year, 40% of the interviewed described some continuing neck symptoms, and a similar proportion reported clinically significant psychological symptoms, of which anxiety about travel was the most conspicuous problem. A quarter were rated as having a poor global social outcome at 1 year.

Schrader *et al.* (1996) did a retrospective questionnaire-based cohort study. 202 Lithuanians were interviewed 1-3 years after experiencing a rear-end collision. No one in the study group had disabling or persistent symptoms as a result of the car accident.

Squires *et al.* (1996) studied 40 patients with a whiplash injury who had been reviewed previously 2 and 10 years after injury. They were assessed again after a mean of 15.5 years by physical examination, pain and psychometric testing. 70% continued to complain of symptoms referable to the original accident. Neck pain was the commonest, but low-back pain was present in half. Radiating pain was more common in those with severe symptoms. Evidence of psychological disturbance was seen in 52% of patients with symptoms. Between 10 and 15 years after the accident 18% of the patients had improved whereas 28% had deteriorated.

Wallis *et al.* (1996) studied 140 consecutive referred patients with chronic neck pain after a motor vehicle accident, using the SCL-90-R psychological profile and the McGill Pain Questionnaire. The length of illness ranged from 6 months to 530 months. In addition to the inclusion symptom of neck pain, the following symptoms were reported: headache (78%), shoulder pain (76%), and arm pain (25%). In addition to physical pain, the following symptoms were reported: disturbance of concentration or memory (69%), dizziness (54%), visual disturbance (37%), irritability (70%), sleep disturbance (65%), and tiredness (40%).

Gimse *et al.* (1997) did a study to identify possible cognitive dysfunctions in a group with persistent problems after whiplash. The whiplash group differed significantly from a closely matched control group on tests of learning and memory, and prolonged divided attention and concentration. *t al.* (1998) compared attentional dysfunctions in 24 whiplash patients with 21 age-matched controls. The results showed that whiplash patients had lower scores on the PASAT and higher scores on the questionnaires (POMS and SCL-90) compared to healthy controls.

Smed *et al.* (1997) studied the prevalence of cognitive function and distress after common whiplash injury. One month after the accident, 85% of the patients had resumed work. Subjective cognitive disturbances, however, were frequent but unrelated to test performances, which were within the normal range. Patients reporting stressful life events unrelated to the injury had more symptoms and elevated levels of distress on all SCL-90-R syndrome scales. At follow-up their distress was unchanged, and subjective cognitive function had deteriorated.

Bylund *et al.* (1998) did a follow-up cohort study of 250 passenger car occupants aged 16-64 injured in car crashes in an urban area in Sweden. Strain of cervical spine was the most common type of injury (55%; 141 injuries), and these injuries accounted for 82% of all sick leave taken within 2.5

years after the injury event. Injury to the cervical spine in 16 of 18 cases resulted in long-term sick leave or dependence on disability pension.

Schmand *et al.* (1998) studied the prevalence of malingering or underperformance in post-whiplash patients, and its impact on their cognitive test results (Amsterdam short term memory test, and a series of conventional memory and concentration tests). The study sample was a highly selected group of 108 patients: 36 were examined as part of a litigation procedure and 72 were examined in the normal outpatient routine. The study showed that the prevalence of underperformance, as defined by a positive score on the malingering test, was 61% (95% CI: 45-77) in the context of litigation and 29% (95% CI: 18-40) in the outpatient clinic ( $p = 0.003$ ). The authors concluded that the prevalence of malingering or cognitive underperformance in late post-whiplash patients is substantial, particularly in litigation contexts.

Wallis *et al.* (1998) used the SCL-90-R symptom checklist to determine the psychological profiles of patients with whiplash-associated headache, with whiplash-associated neck pain without headache, with post-traumatic or non-traumatic headache and with the normal population. Patients with whiplash-associated headache were not significantly different from those with other forms of post-traumatic headache or with whiplash-associated neck pain without headache. However, when compared to normal data, patients with non-traumatic headache exhibited higher scores on all subscales, whereas patients with whiplash-associated headache differed from the normal sample only on somatization, obsessive-compulsive, depression and hostility subscales, and the global severity index.

Partheni *et al.* (2000) did a prospective cohort study using a standard questionnaire. The subjects were 180 accident victims that were consecutively recruited following Emergency ward presentation. They were followed for 6 months. In the initial 4 weeks after the accident, accident victims reported neck pain, headache, shoulder pain, limb numbness of pain, and dizziness. However, at 4 weeks more than 90% had recovered from these, the remainder of the subjects having minor symptoms (not requiring therapy), and returning to their pre-accident state of health (which included minor symptoms). There were no cases of chronic disability.

Richter *et al.* (2000) made an analysis of 1176 whiplash-type neck distortions taken from a total of 3838 restrained car driver incident reports. More than 1,000 questionnaires were sent to the injured; only 138 (12%) returned the questionnaire. Of the 138, 121 (88%) indicated that they had suffered or were still suffering from their symptoms. The percentages of the various complaints were as follows: pain (74%), tension (6%) and stiffness (5%) in the head (27%), neck (55%) and shoulder (8%). A correlation between the severity of the accompanying injuries and duration of complaints was found. It needs to be stressed that the low response rate raises doubts about the validity of the outcomes.

## 4. PROGNOSTIC FACTORS

In this section, the prognostic importance of single or grouped determinants is described.

1. Signs and symptoms
2. Radiological findings
3. Socio-demographic and economic factors
4. Psychological factors
5. Crash-related factors

Appendix A provides a table in which the information from this chapter is summarized.

### 4.1. SIGNS AND SYMPTOMS

#### Conclusions of the QTF

Radanov *et al.* (1991) found that finger paresthesia was predictive of persistence of symptoms for 6 months after injury in a series of 78 patients who attended primary care practices within 7 days of a whiplash injury. Radanov *et al.* (1993) also examined predictors of persistence of headache in subjects with common whiplash. The study suggested that pre-trauma headache and neck pain are associated with a delay in recovery from trauma-related headache after whiplash injury. Norris *et al.* (1983) found that the presence of musculoskeletal or neurologic signs within 3 days of motor vehicle collision (MVC), as indicated by severity group, is predictive of outcome at 6 or more months later.

#### Update of the above conclusions by RAND Europe

Radanov *et al.* (1994b) analyzed the significance of the interplay between somatic and psychosocial factors in influencing the course of recovery of 117 whiplash patients. Follow-ups were carried out at 3, 6 and 12 months. Results indicate that poor recovery is related to severity of injury in addition to some pre-traumatic factors (previous history of head trauma and headache) and initial injury-related reaction (i.e. sleep disturbances, reduced speed of information processing and nervousness). However, psychosocial factors did not prove predictive at any follow-up examination. The authors concluded that symptoms suggesting a more severe neck injury appear to be particularly related to delayed recovery from common whiplash.

Petterson *et al.* (1995) evaluated the relationship between spinal canal width and chronic symptoms after whiplash injury. The sagittal diameter of the cervical spinal canal was measured on standard lateral radiographs of 48 consecutive whiplash patients with acute whiplash injury after car accidents. A follow-up was done 12 months after injury. It was concluded that the spinal canal was significantly smaller in the patients with persistent symptoms than in the asymptomatic group. A significant difference was also found between men and women.

Mayou *et al.* (1996) examined the 3 months and one year outcomes (physical symptoms, mental state, quality of life, effects on travel and psychological status) in whiplash patients. The study focused on factors at initial presentation and at 3 months which predict physical, psychological and social 1 year outcome, and processes and significance of compensation proceedings. For physical symptoms, the principal predictors were report of neck symptoms immediately after the accident, gender (with women being more at risk than men), and driver-passenger status (with passengers being more at risk than drivers). For mental state, the main predictors of anxiety and depression at 1 year were a high neuroticism score on a standard personality questionnaire and a history of consultation for psychological problems before the accident. However, these variables did not predict post-traumatic disorder or travel-anxiety, both of which were best predicted by an initial report of 'horrific memories' of the accident. For social outcome, psychological factors were the only significant predictors of a poor overall social outcome. There were no clear differences in physical or

psychological outcome between those who were claimants and those who were not, and between those who settled early and those who settled late. To conclude, the occurrence of neck complaints are predicted by the report of physical symptoms at the baseline interview but not by any of our initial psychological and social variables or by compensation. There was no association at 1 year between psychological and physical symptoms, but there was a strong correlation between psychiatric status and the global rating of social impairment.

Radanov *et al.* (1996) did a study to establish criteria for delayed recovery after whiplash injury using a 1-year prospective cohort study. This study builds on an earlier study by the same author (Radanov *et al.*, 1994b, see above). The study included 117 whiplash patients referred from primary care and 16 patients recruited from an insurance company. All patients underwent neurological, radiological and psychosocial factors assessment and testing of personality traits, well-being, cognitive ability, and cognitive functioning. The following variables are in significant relationship with poor outcome at 1 year: impaired neck movement, history of pre-traumatic headache, history of head trauma, higher age, initial neck pain, initial headache intensity, nervousness score, neuroticism score and test score on focused attention. Employing these variables, correct prediction of outcome at 1 year was found in 88% of patients recruited from the insurance company, and in 96% of the primary care group. It was concluded that a comprehensive assessment of whiplash patients early after trauma enables physicians to identify patients at risk of delayed recovery.

Schrader *et al.* (1996) did a retrospective questionnaire-based cohort study. 202 Lithuanians were interviewed 1-3 years after experiencing a rear-end collision. The results were compared with the results in a sex- and age- matched control group of uninjured individuals. There was no significant difference found. There was no relation between the impact severity and degree of pain. A family history of neck pain was the most important risk factor for current neck symptoms. This study received a great amount of criticism because of the weak study design. As the previous study did not allow for a precise and reliable estimation of the incidence, severity, and duration of initial symptoms, Obelieniene *et al.* (1999) performed a prospective controlled cohort study in 210 Lithuanian citizens recently exposed to a rear end collision. Initial pain was reported by 47% of accident victims; 10% had neck pain alone; 18% had neck pain together with headache, and 19% had headache alone. The median duration of the initial neck pain was 3 days and the maximum duration 17 days. The median duration of headache was 4.5 hours and the maximum duration was 20 days. After 1 year, there were no significant differences between the accident victims and the control group concerning frequency and intensity of these symptoms.

Dolinis (1997) examined relationships between vehicle and occupant factors and the incidence of whiplash in drivers with recent experience of a rear-impact in a road traffic accident. A cohort of 246 car drivers (1000 people approached; response rate: 25%) in the Adelaide metropolitan area was recruited and information from these people was obtained through a structured telephone interview. Two factors were identified as independent risk factors for 'whiplash' injury: a history of neck pain and female sex. There was no evidence that the driver's occupation or level of education are predictors of occurrence. Light vehicles and not being aware of the impending collision, increased the risk of whiplash injury. However, the elevated relative risks were not significant.

Gargan *et al.* (1997) studied 50 consecutive patients presenting at an accident department after rear-end vehicle collisions and recorded symptoms and psychological test scores within one week of injury, at three months, and at two years. The range of neck movement was noted at three months. Within one week of injury, psychological test scores were normal in 82% of the group but became abnormal in 81% of the patients with intrusive or disabling symptoms at over three months and remained abnormal in 69% at two years. The clinical outcome after two years could be predicted at three months with 76% accuracy by neck stiffness, 74% by psychological score, and 82% by a combination of these variables.

Satoh *et al.* (1997) did a prospective study, including 3167 patients with whiplash injuries who had been in rear-end collisions and who continued to elicit treatment-receiving behavior at 1.5, 3 and 6

months post-trauma. Results showed that being female, use of emergency vehicle transportation, and early complaint of symptoms were significantly correlated with persistence of symptoms 6 months post-trauma, while employment status had no significant association with continued treatment.

Suissa *et al.* (2001) studied the profile of recovery from whiplash and assessed whether presenting signs and symptoms immediately after the crash were predictive of whiplash prognosis. They formed a population-based incident cohort of all 2627 individuals who sustained a whiplash injury resulting from a MVC in Quebec in 1987, and followed these patients for up to 7 years. Data were obtained from the universal automobile insurance plan. The median recovery time was 32 days, and 12% of subjects had still not recovered after 6 months. The signs and symptoms that were found to be independently associated with a slower recovery from whiplash, besides female gender and older age, are neck pain on palpation, muscle pain, pain or numbness radiating from the neck to arms, hands or shoulders, and headache. Together, these factors in older females (age 60) predicted a median recovery time of 262 days, compared with 17 days for younger males (age 20) who do not have this profile. The authors conclude that whiplash patients presenting with specific signs and symptoms will have a longer recovery period, and that these patients can easily be identified and closely monitored and targeted for the evaluation of early intervention programs aimed at managing whiplash patients with a poor prognosis.

Hartling *et al.* (2001) did a retrospective cohort study to (1) evaluate the utility of the Quebec Classification of WAD as an initial assessment tool; (2) assess its ability to predict persistence of symptoms at 6, 12, 18, and 24 months post-collision; and (3) examine one potential modification to the Classification. In total, 380 patients were categorized according to the Classification based on signs and symptoms documented in their emergency medical chart. Data were gathered regarding symptoms, treatments received, effects on usual activities, crash circumstances, and personal factors. The Classification was prognostic in that risk for WAD at 6, 12, 18, and 24 months increased with increasing grade. Analyses supported modification of the Classification to distinguish between Grade II cases of WAD with normal or limited range of motion. The greatest risk for long-term symptoms was seen among the group of patients with both point tenderness and limited range of motion.

## **4.2. RADIOLOGICAL FINDINGS**

### Conclusions of the QTF

The prognostic importance in WAD of radiological findings, including osteophytes, end-plate sclerosis, angular deformity, pre-existing degenerative changes, was not examined in any accepted studies. In the cross-sectional study of Van der Donk *et al.* (1991), X-ray evidence of disc degeneration was associated with non-specific neck pain in men but not in women, while osteoarthritis was not associated with neck pain.

### Update of the above conclusions by RAND Europe

Borchgrevink *et al.* (1997) evaluated if MRI within two days after a motor vehicle accident could reveal pathology of importance for understanding long term disability after whiplash. It was concluded that MRI within two days after the whiplash injury could not detect pathology connected to the injury nor further predict symptoms development and outcome.

Petterson *et al.* (1997) evaluated the relationship between MRI findings and clinical findings after whiplash injury for 39 patients. MRI and clinical examination were performed in a blinded manner at a mean of 11 days after trauma. The procedure was repeated at a 2-year follow-up visit. Two patients could not be examined with the second MRI. The authors found 13 patients (33%) with medullary or dura impingement over the 2-year follow-up period. At the follow-up examination all patients with medullary impingement had persistent or increased symptoms and 3 of 27 patients (11%) with no or slight changes on MRI had persistent symptoms. No ligament injuries were diagnosed.

Voyvodic *et al.* (1997) investigated the prognostic significance of features seen on MRI of patients with whiplash injury following relatively minor road traffic crashes. MRI was obtained shortly and at 6 months after the crash. Clinical examinations were used to assess the status of patients initially and at 6 months. The results of the independent MRI and clinical investigations were then examined for association using statistical tests. Initial MRI was performed on 29 patients, of whom 19 had repeat studies at 6 months. Apart from spondylosis and loss of lordosis, only one abnormality was detected: an intramedullary lesion consistent with a small cyst or syrinx. There were no statistically significant associations between the outcome of injury and spondylosis or loss of lordosis. No significant changes were found when comparing the initial and follow-up MRI.

### **4.3. SOCIODEMOGRAPHIC AND ECONOMIC FACTORS**

#### Conclusions of the QTF

In a study of Radanov *et al.* (1991), the symptomatic and asymptomatic groups at 6 months did not differ in sex, education, injury mechanism, accident fault, or time from injury to initial study examination. Older age was associated with persistent symptoms. MacNab (1971) reported that among 145 patients, all of whom had been involved in litigation, symptoms had not remitted in two years after settlement in 121. However, the QTF concluded that this study was poorly defined.

#### Update of the above conclusions by RAND Europe

As part of the Quebec whiplash-associated disorder cohort study (1995), Harder *et al.* (1998) investigated socio-demographic and crash-related factors measured at the time of the crash. For the 1551 subjects a slower recovery from whiplash in this cohort, the socio-demographic factors that were found to be independently associated with a slower recovery from whiplash in this cohort are female gender, older age, having dependents, and not having full-time employment. Factors that were not independently associated with a slower recovery are area of residence, marital status, and net income. It was concluded that several socio-demographic and crash-related factors are independently associated with a slow and costly recovery from whiplash injury. They are easily measurable at the time of the crash and combined so as to be simply incorporated in intervention programs aimed at early identification and management of whiplash patients with a poor prognosis.

Swartzman *et al.* (1996) examined the effect of litigation on adjustment to chronic pain. Questionnaire data were obtained from 41 patients in the process of litigation and 21 patients who had completed litigation. Subjects completed self-report measures assessing several factors. There were no significant group differences in demographic characteristics, employment status, or psychological distress. Litigants, however, reported more pain than did post-litigants. That litigation status did not predict employment status suggests that secondary gain does not figure prominently in influencing the functionality of these patients.

Dolinis (1997) identified two factors as independent risk factors for 'whiplash' injury, namely a history of neck pain and female sex [for more information on this study, see Signs and symptoms].

Brault *et al.* (1998) assessed the relation between both gender and impact severity, and the presence, severity, and duration of WAD. This was done in an experimental study in which 42 persons were exposed to controlled low-speed rear-end automobile collisions. Approximately 29% and 38% of the subjects exposed to the 4 km/h and 8 km/h speed changes, respectively, experienced WAD symptoms, with cervical symptoms and headaches predominating. There were no significant differences in the presence and severity of WAD between men and women at 4 km/h and 8 km/h or in the duration of WAD at 8 km/h. There was also no significant difference in the presence, severity, and duration of WAD between 4 km/h and 8 km/h. No pre-impact measures were predictive of WAD.

Cassidy *et al.* (2000) studied whether the incidence and prognosis of whiplash injury from motor vehicle collisions may be related to eligibility for compensation for pain and suffering. In Canada, the tort-compensation system for traffic injuries (which included payments for pain and suffering) was changed to a no-fault system (which did not include such payments) in January 1995. The authors studied a population-based cohort of 7462 persons who filed insurance claims for traffic injuries. The 6-months cumulative incidence of claims was 417 per 100,000 persons in the last 6 months of the tort system, as compared with 302 and 296 per 100,000 in the first and second 6 months of the no-fault system. The incidence of claims was higher for women than for men in each period. The incidence decreased by 43% for men and 15% for women. The median time from the date of injury to the closure of a claim decreased from 433 days to 194 and 203 days respectively. The intensity of neck pain, the level of physical functioning, and the presence or absence of depressive symptoms were strongly associated with the time to claim closure in both systems.

Cote *et al.* (2001) investigated the association between neck pain, physical functioning, depressive symptomatology and time-to-claim-closure in a Saskatchewan cohort of 5398 whiplash claimants in 1994-1995. In 1995, the insurance system changed from tort to no-fault, eliminating compensation for pain and suffering. Under tort, a 10-point increase in pain reduced the claim-closure rate by 13-24% while a 10-point increase in physical functioning increased it by 17%. Depressive symptomatology reduced the claim-closure rate by 37%. Under no-fault, a 10-point increase in pain reduced the claim-closure rate by 18% while a 10-point increase in physical functioning increased it by 10-35%. The presence of depressive symptomatology reduced the claim-closure rate by 36%. The results suggest that lower pain, better function and the absence of depressive symptoms are strongly associated with faster time-to-claim-closure and recovery after whiplash, independent of the insurance system.

#### **4.4. PSYCHOLOGICAL FACTORS**

##### Conclusions of the QTF

Radanov *et al.* (1991) showed that there was no statistically significant association of life history, personality traits, and 'current psychosocial stress' with persistence of symptoms at 6 months. Self-report of cognitive impairment was associated with system persistence. In 1992, Radanov *et al.* reported that there was no evidence for differences in attentional processing between 'common whiplash' and patients with Barré-Léiou syndrome, although whiplash patients tended to report more disturbance of cognitive function. The authors suggest that the self-reported cognitive impairment may have been related to the sudden nature of whiplash injury, while in Barré-Léiou syndrome there is gradual onset, allowing time for adaptation. Finally, Van der Donk *et al.* (1991) have suggested that neurotic personality traits are associated with neck pain in the general population. However, this was a cross-sectional and it is not possible to determine whether the presence of neck pain negatively affected personality or personality was a determinant of persistent neck pain.

##### Update of the above conclusions by RAND Europe

Radanov *et al.* (1996a) evaluated the course of psychological variables during a 2-year follow-up in patients after common whiplash of the cervical spine. 21 patients who suffered trauma-related symptoms over 2 years were compared with 21 age, gender, and education pair-matched patients, who showed complete recovery from trauma-related symptoms during the 2-year follow-up. Significant differences between the groups and significant deviation of scores over time were found on the Well-Being and Nervousness Scales. There was a lack of significant difference between the groups on the Depression Scale, indicating a possible somatic basis for changes in psychological functioning in the investigated sample. The authors concluded that patients' psychological problems are rather a consequence than a cause of somatic symptoms in whiplash.

Borchgrevink *et al.* (1997a) examined to what extent personality traits and psychiatric symptoms can predict recovery from common neck sprain injuries. In addition, they compared the personality and



psychiatric profiles of patients with neck sprain injuries with (a) a group of health personnel; (b) patients with localized musculoskeletal pain; and (c) patients with major depression. The Million Clinical Multi-axial Inventory (MCMI-I) was completed at time of occurrence (intake) and 6 months after the injury. The results indicated that the neck sprain group did not differ on the MCMI-I neither at intake nor 6 months later. The total neck sprain patients group was significantly different from patients with major depression on all scales of MCMI-I, but not significantly different compared to patients with localized musculoskeletal pain. Compared to a group of health personnel, there were only few significant differences. The study does not support the view that pre-morbid personality traits can predict outcome for neck sprain patients.

Karlsborg *et al.* (1997) studied 34 consecutive cases of whiplash injury. The patients were examined clinically three times; within 14 days, after 1 month, and 7 months post-injury. In addition, MRI of the brain and the cervical spine, neuropsychological tests and motor evoked potential (MEP) were done one month post-injury and repeated after 6 months, if abnormalities were found. The total recovery rate was 29% after 7 months. MRI was repeated in 6 patients. The correlation between MRI and the clinical findings was poor. Cognitive dysfunction as a symptom of brain injury was not found. Stress at the same time predicted more symptoms at follow-up. All MEP examinations were normal.

Cote *et al.* (2000) determined whether independent associations exist between a history of neck injury related to a motor vehicle collision, and: (1) graded neck pain in the past 6 months; (2) headaches in the past 6 months; and (3) depressive symptomatology during the past week. A history of neck injury was positively associated with low intensity/low disability neck pain, and with disabling neck pain. Similarly, the authors found a positive association between a history of neck injury in a motor vehicle collision and headaches that moderately/severely impact on one's health. No association was found between neck injury and depressive symptomatology. The cross-sectional analysis suggests that neck pain and severe headaches are more prevalent in individuals with a history of neck injury from a car collision. However, the results should not be used to infer a causal relationship between whiplash and chronic neck pain and headaches.

#### **4.5. CRASH-RELATED FACTORS**

This section discusses a few articles focusing on the relationship between accident mechanisms and the development of chronic whiplash associated disorders resulting from a motor vehicle accident. Although many studies focus on the biomechanical aspects of whiplash injuries, in this section we will only focus on those that discuss crash-related factors that affect the prognosis of a person involved in a whiplash injury. The QTF did not include these articles in its literature review. We, however, thought it is worth to briefly describe those crash-related factors that might have an effect on the development of chronic whiplash associated disorders.

Sturzenegger *et al.* (1994) assessed the relationship between accident mechanisms and initial findings after whiplash injury. 137 patients were interviewed and examined within 7.2 days after trauma. The study showed that passenger position in the car, use of seat belt, and the presence of a head restraint showed no significant relationship with findings. Rotated or inclined head position at the moment of impact was associated with a higher frequency of multiple symptoms ( $p=0.045$  and  $0.008$ ), with more severe symptoms and signs of musculoligamentary cervical strain ( $p=0.048$  and  $0.038$ ) and of neural, particular radicular ( $p=0.031$  and  $0.019$ ), damage. Unprepared occupants had a higher frequency of multiple symptoms ( $p=0.031$ ) and more severe headache ( $p=0.046$ ). Rear-end collision was associated with a higher frequency of multiple symptoms ( $p=0.006$ ), especially of cranial nerve or brainstem dysfunction ( $p=0.00003$ ). It was concluded that three features of accident mechanisms were associated with more severe symptoms: an unprepared occupant, rear-end collision (with or without subsequent frontal impact), and rotated or inclined head position at the moment of impact.

As part of the Quebec whiplash-associated disorder cohort study (1995), Harder *et al.* (1998) investigated socio-demographic and crash-related factors measured at the time of the crash. For the

1551 subjects a slower recovery from whiplash in this cohort, significant crash-related factors are occupancy in a truck or bus, being a passenger in the vehicle, colliding with a moving object, and being in a head-on perpendicular collision. Factors that were not independently associated with a slower recovery from whiplash are severity of the crash, seatbelt use, and the authorized speed limit in the crash location. It was concluded that several socio-demographic and crash-related factors are independently associated with a slow and costly recovery from whiplash injury. They are easily measurable at the time of the crash and combined so as to be simply incorporated in intervention programs aimed at early identification and management of whiplash patients with a poor prognosis.

Berglund *et al.* (2000) conducted a cohort study to determine whether exposure to a rear-end collision, without or with whiplash injury, is associated with future neck or shoulder pain. Drivers exposed to a rear-end collision were divided into two subgroups, without reported whiplash injury (n = 204) and with reported whiplash injury (n = 232). Two comparison groups, unexposed to motor vehicle collisions, consisting of 1599 and 2089 persons, were selected. A questionnaire concerning neck or shoulder pain and other subjective health complaints was mailed to all the study subjects at follow-up in 1994, 7 years after the rear-end collision. The relative risk of neck or shoulder pain at follow-up was 1.3 (95% CI 0.8-2.0) in the exposed subjects without whiplash injury compared with the unexposed. The corresponding relative risk in subjects with whiplash injury was 2.7 (95% CI 2.1-3.5). We conclude that there is no increased risk of future neck or shoulder pain in drivers who did not report whiplash injury in connection with a rear-end collision 7 years earlier. In drivers with reported whiplash injury, the risk of neck or shoulder pain 7 years after the collision was increased nearly three-fold compared with that in unexposed subjects.

## 5. TREATMENT OPTIONS FOR WHIPLASH

Based on the work of the QTF and our review of scientific literature, we identified a number of specific treatments for whiplash. In this chapter, we will summarize the evidence regarding efficacy and effectiveness of these treatments, based on the results of the studies we accepted in our literature review. The following sets of treatment options will be discussed:

1. Immobilization
2. Activation
3. Passive modalities/electrotherapies
4. Surgical treatment
5. Injections
6. Pharmacologic interventions
7. Psychosocial interventions
8. Multidisciplinary treatment
9. Other interventions

Summary treatment tables can be found in Appendix B.

### 5.1. IMMOBILIZATION

#### 5.1.a) Collars

##### Conclusions of the QTF

Cervical collars are prescribed to immobilize the neck in whiplash. The QTF reviewed studies that addressed the extent to which collars restrict cervical range of motion in normal subjects and the extent to which they relieve the clinical manifestations of whiplash. It was concluded that collars have little effect on the cervical range of motion in healthy adults and that no research was found addressing their independent efficacy or effectiveness for whiplash. However, some information was available from small trials in which collars were prescribed for control patients. From these studies, the QTF concluded that collars may promote immobility, which can delay recovery.

##### Update of the above conclusions by RAND Europe

In a controlled clinical trial (Gennis *et al.*, 1996) 250 patients (of which 196 were available for follow-up) were assigned to receive a soft cervical collar or no collar based on their medical record numbers. The groups were similar in age, gender, seat position in the car, seat belt use, and initial pain score. For these patients, pain after 6 weeks was registered. The groups showed no difference in follow-up pain category and there was no significant difference between the two groups in complete recovery. The researchers concluded that soft cervical collars do not influence the degree or duration of persistent pain.

Two other studies compared immobilization (through cervical collars) and activation. A single-blinded, randomized treatment study (Borchgrevink *et al.*, 1998) compared the long-term consequences (six months after the accident) of whiplash neck sprain injuries in patients treated with two different regimes during the first 14 days after the car accident. Patients in the first group were encouraged to act as usual, whereas patients in the second group were given time off from work and were using a soft neck collar. The study showed that there was a significantly better outcome for the act-as-usual group in terms of subjective symptoms, including pain localization, pain during daily activities, neck stiffness, memory, and concentration, and in terms of visual analog scale measurements of neck pain and headache.

In a randomized clinical trial study (Giebel *et al*, 1997) the treatment with collar immobilization for three weeks was tested against a certain scheme of physiotherapy in a prospective duration. Endpoints were defined as state of health, pain and costs. 97 patients with whiplash injuries were splitted by randomization into two groups. 50 healthy persons served as a control group. The study concluded that physiotherapy for treatment of neck sprain has clear advantages over the treatment with collars with regard to state of health and pain, and that it seems to be economically favorable.

### **5.1.b) Prescription of rest**

#### Conclusions of the QTF

Prescription of rest in the first few days after an accident is quite common for whiplash. The QTF found no studies designed to evaluate the independent effect of rest on whiplash. However, the QTF did find trials in which prescription of rest was combined with soft collars and analgesia. From these studies, it concluded that prolonged periods of rest are detrimental to recovery from whiplash.

#### Update of the above conclusions by RAND Europe

In recent years, there also were no studies published on the independent effect of rest on whiplash. A study by Borchgrevink published in 1998 (see above) compared the long-term consequences of two different treatment regimes during the first 14 days after the car accident. The study showed that there was a significantly better outcome for the act-as-usual group than for patients that were given time off from work and were using a soft neck collar.

## **5.2. ACTIVATION**

### **5.2.a) Manipulation**

#### Conclusions of the QTF

The QTF did accept two studies about manipulation. The first study addressed the duration of effect of a single manipulation in reducing passive end-range asymmetry. The study focuses on people with asymmetry > 10 degrees with and without a history of neck trauma. Immediately after the single adjustment, the mean degree of asymmetry was corrected in both groups. 48 hours post adjustment, the mean degrees of asymmetry in the neck trauma group approached their pre-treatment mean level. In the group without history of neck injury, the asymmetry was returning, but not to pre-adjustment levels.

The second study found a greater reduction in pain immediately after a single manipulation treatment than was associated with mobilization, although pre-treatment pain was greater in the manipulation group. A secondary analysis by the same author indicated that the difference in improvement of pain was no longer observed when pre-treatment pain score was controlled in statistical analysis.

#### Update of the above conclusions by RAND Europe

Woodward (1996) undertook a retrospective study to determine the effects of chiropractic treatment in a group of 28 patients who had been referred with chronic whiplash syndrome. The severity of patients' symptoms was assessed before and after treatment using the Gargan and Bannister (1990) classification. 26 patients improved following chiropractic treatment (U=34, p<0.001). The encouraging results from this retrospective study merit the instigation of a prospective randomized clinical trial to compare conventional with chiropractic treatment in chronic whiplash injury.

## 5.2.b) Mobilization

### Conclusions of the QTF

The QTF did not find studies that addressed the independent effects of mobilization. However, there were several accepted RCTs on the efficacy of mobilization in combination with other physiotherapeutic modalities in whiplash. From these studies, the QTF concluded that mobilization techniques can be used as an adjunct to strategies that promote activation. In combination with activating interventions, they appear to be beneficial in the short term, but the long-term benefit has not been established.

### Update of the above conclusions by RAND Europe

In recent years, a couple of studies compared immobilization and mobilization. These studies have been described above (see the section on collars). Below, you find a short summary of these studies. Borchgrevink *et al.* (1998) showed that there was a significantly better outcome for the act-as-usual group in terms of subjective symptoms and in terms of visual analog scale measurements of neck pain and headache than for patients who were given time off from work and were using a soft neck collar. Giebel *et al.* (1997) concluded that physiotherapy for treatment of neck sprain has clear advantages over the treatment with collars with regard to state of health and pain, and that it seems to be economically favorable.

McKinney (1994) studied the outcomes of differing treatment regimes in acute whiplash patients in three randomized groups. He tried to identify which features of physiotherapeutic practice correspond with improved outcome. He showed that after 1 and 2 months, there was a significant improvement in cervical movements and in patients' perception of their neck pain severity, in actively mobilized patients, including those who were instructed about postural correlation and mobilization techniques. The benefit conferred on this group was still evident 2 years post injury. He concludes that self-reliance with exercises used when symptoms are troublesome and postural advice can play a significant role in the recovery process.

In a randomized treatment study with a follow-up period of six months, Soderlund *et al.* (2000) compared two different home exercise programs for patients with acute WAD. A total of 59 symptomatic patients with acute whiplash injury were randomized to a regular treatment group (RT) and an additional-exercise treatment group (AT). Patients given an additional exercise did not improve more than patients with regular treatment. Only one item, 'Ability to decrease pain', showed a significant difference between the groups: the AT group had a significant increase between 3 and 6 months whilst values in the RT group decreased. The authors conclude that this home exercise program, including training of neck and shoulder range of motion (ROM), relaxation and general advice seems to be sufficient treatment for acute WAD patients when used on a daily basis. Patients reporting low self-efficacy and high disability levels may profit from more attention initially, as these psychological factors are significant predictors of pain at long-term follow-up.

Rosenfeld *et al.* (2000) conducted a prospective randomized trial in 97 patients with a whiplash injury caused by a MVC. The study evaluates early active mobilization versus a standard treatment protocol and the importance of early versus delayed onset of treatment. Patients were randomized to four groups. Active versus standard treatment and early (within 96 hours) versus delayed (after 2 weeks) treatment. Measures of range of motion and pain were registered initially and at 6 months. Eighty-eight patients (91%) could be followed up at 6 months. Active treatment reduced pain more than standard treatment ( $P < 0.001$ ). When type and onset of treatment were analyzed, a combined effect was seen. When active treatment was provided, it was better when administered early, and if standard treatment was provided, it was better when administered late for reduction of pain ( $P = 0.04$ ) and increasing cervical flexion ( $P = 0.01$ ). The authors conclude that in WAD patients caused by a MVC treatment with frequently repeated active submaximal movements combined with mechanical

diagnosis and therapy is more effective in reducing pain than a standard program of initial rest, recommended use of a soft collar, and gradual self-mobilization.

### **5.2.c) Exercise**

#### Conclusions of the QTF

No studies appeared which address the independent effects of exercise. However, active exercises were included as part of the interventions in several studies. The cumulative evidence suggests that active exercises as part of a multimodal intervention can be beneficial in the short and long term.

#### Update of the above conclusions by RAND Europe

In 1995 a study appeared (Fitz-Ritson, 1995) that assessed the effect of 'phasic' exercises, including rapid eye-head-neck-arm movements, on patients with chronic cervical injuries. A randomized, controlled, double blind study involving 30 chronic patients allocated those patients to either group 1 or group 2. Group 1 had standard exercises (stretching/isometric/isokinetic) and chiropractic therapy. Group 2 had 'phasic' exercises and chiropractic therapy. After eight weeks, Group 1 improved by 7,4% ( $p > .05$ ) and group 2 improved by 48,3% ( $p > .001$ ). It was concluded that any rehabilitation program for chronic neck-injured patients should involve exercises that address the following: eye-head-neck-arm coordinated movements, coordination of the entire vertebral column, and return the 'phasic' component of the musculature to functional levels.

### **5.2.d) Traction**

#### Conclusions of the QTF

The QTF did not find research regarding the independent benefit of traction in whiplash. One study evaluated different types of traction in 100 patients with cervical spine disorders, including 11 whiplash patients. For all three kinds of traction (static traction, intermittent traction and manual traction), there was a significantly greater change in forward flexion and right rotation than in controls. There were, however, no clinically or statistically significant differences in ROM change in extension left or right bending, or left rotation, or in change of pain severity. Patients in the control group showed increases in ROM in each direction during the study and a decrease in mean pain score. This suggests that even without traction there is improvement in pain severity and ROM over a two-month period in cervical spine disorders.

#### Update of the above conclusions by RAND Europe

In a retrospective study of 58 outpatients (Swezey *et al*, 1999) the efficacy of home cervical traction was studied. The patients were classified as Grade 1 to Grade 3 according to the QTF of Whiplash-Associated Disorders Cohort Study. Of the Grade 1 patients (mild) 100% improved. Of the Grade 2 patients (moderate) 77% improved, 11,5% were unchanged and 11,5% felt their symptoms were aggravated by cervical traction. Of the Grade 3 patients (patients with radiculopathy) 90% improved. It was concluded that a brief (3-5 min), over-the-door home cervical traction modality provided symptomatic relief in 81% of the patients with mild to moderately severe (Grade 3) cervical spondylosis syndromes.

### **5.2.e) Postural alignment and advice**

The QTF did not find any research regarding postural alignment. They found one study in which advice on posture was part of the interventions. RAND Europe found no studies which addressed the independent effect of postural alignment and advice.

### **5.3. PASSIVE MODALITIES/ELECTROTHERAPIES**

#### **5.3.a) Transcutaneous Electrical Nerve Stimulation (TENS)**

The QTF and RAND Europe did not find acceptable studies regarding TENS.

#### **5.3.b) Pulsed Electromagnetic Treatment (PEMT)**

##### Conclusions of the QTF

A study focusing on whiplash patients compared the PEMT collar to a sham PEMT collar in patients referred from an emergency department within 72 hours of MVC. All patients received NSAIDs and advice. Mean pain rating declined more quickly in the PEMT group than in controls. ROM score improved up to 4 weeks in the PEMT group but not in the control group. Use of analgesics also declined in the PEMT group but not in the control group. At 4 weeks, 45% of PEMT patients and 60% of control patients chose to add physiotherapy to their treatment. Secondary analysis shows that these proportions are not significantly different. Improvement continued in both groups to 12 weeks; however, the rate of improvement in the control group increased relative to that in the PEMT group, so that by the end of 12 weeks, there was no significant difference in pain rating or ROM between the two groups (Foley-Nolan, 1992).

##### Update of the above conclusions by RAND Europe

No additional studies analyzing the effectiveness of PEMT were found.

#### **5.3.c) Electrical Stimulation, Ultrasound, laser, Short Wave Diathermy, Heat, Ice, Massage**

The QTF and RAND Europe did not find any acceptable studies regarding the independent effect of any of these treatments for whiplash. Some of these treatments were part of the combination of physiotherapeutic modalities in a couple of studies.

### **5.4. SURGICAL TREATMENT**

#### **5.4.a) Discectomy and anterior cervical fusion**

##### Conclusions of the QTF

No studies accepted.

##### Update of the above conclusions by RAND Europe

Algers *et al.* (1993) studied 20 patients operated on with discectomy and anterior cervical fusion because of chronic symptoms after whiplash injury. They were examined 4 years after surgery, and the commonest indications for surgery were disabling headache and neck pain and radiographically verified disc protrusion. At follow-up, 11 patients had reduced headache and neck pain, while paresthesia and radicular pain were diminished in 9 patients. Based on Robinson's criteria for the evaluation of surgical results, 2 patients had good, 9 had fair, and 9 had poor results.

#### **5.4.b) Occipital nerve release**

##### Conclusions of the QTF

No studies accepted.

#### Update of the above conclusions by RAND Europe

One study (Magnusson *et al*, 1996) analyzed the results of 18 greater occipital nerve release in 13 patients. All patients had deep aching pain in the occipital area due to a whiplash trauma, and in all cases the pain was relieve temporarily by local anesthesia of the occipital nerve. The time from accident to operation was 6 to 96 months. The results of 13 (72.2%) operations were reported as good or excellent, although complete pain relief was not attained in any patient. It was concluded that neurolysis of the greater occipital nerve after whiplash injury can give meaningful pain relief in selected patients.

#### **5.4.c) Percutaneous radiofrequency neurotomy**

##### Conclusions of the QTF

This type of treatment is not mentioned in the literature review of the QTF.

##### Update of the above conclusions by RAND Europe

Four articles on percutaneous radiofrequency neurotomy were published recently (Lord, 1995; Lord, 1996; Wallis, 1997; and McDonald, 1999). All studies were published by the same group of authors.

In 1995, an audit (Lord, 1995) was conducted to determine whether it is justified to set-up a randomized, double-blind, controlled study on new operative techniques for the treatment of pain from the cervical zygapophyseal joints. Of the 10 patients who underwent third occipital neurotomy, only 4 obtained long-lasting relief. Of the 10 patients who underwent lower cervical branch neurotomy, 7 obtained complete pain relief for clinically useful periods and were able to resume their activities of daily living and employment. After procedures at all levels, a brief period of postoperative pain was experienced by the patients and ataxia was a side effect of third occipital neurotomy.

To follow-up on the previous study, a randomized, double-blind trial (Lord, 1996b) compared (a) percutaneous radiofrequency neurotomy in which multiple lesions were made and the temperature of the electrode making the lesions was raised to 80 degrees C; and (b) a control treatment using an identical procedure except that the radiofrequency current was not turned on. 24 patients who had pain in one or more cervical zygapophyseal joints after an automobile accident were evenly distributed between the two treatments. The median time that elapsed before the pain returned to at least 50 percent of the preoperative level was 263 days in the active-treatment group and 8 days in the control group ( $p=0.04$ ). At 27 weeks, seven patients in the active-treatment group and one in the control group were free of pain. Five patients in the active-treatment group had numbness in the territory of the treated nerves, but none considered it troubling. In patients with chronic cervical zygapophyseal-joint pain confirmed with double-blind, placebo-controlled local anesthesia, percutaneous radio-frequency neurotomy with multiple lesions of target nerves can provide lasting relief.

A randomized, double-blinded, placebo-controlled trial (Wallis, 1997) studied the resolution of psychological distress of whiplash patients following treatment by radiofrequency neurotomy. Pain and psychological status of 17 patients with a single painful cervical zygapophyseal joint were evaluated pre-operatively and 3 months post-operatively by medical interview and examination, a visual analogue pain scale, the McGill Pain Questionnaire, and the SCL-90-R psychological questionnaire. All patients who obtained complete pain relief exhibited resolution of their pre-operative psychological distress. Because psychological distress resolved following a neurosurgical treatment which completely relieved pain, without psychological co-therapy, it is concluded that psychological distress exhibited by these patients was a consequence of the chronic somatic pain.



A randomized controlled trial (McDonald, 1999) studied the long-term efficacy of percutaneous radiofrequency neurotomy in the treatment of chronic neck pain. Between 1991 and 1996, radiofrequency neurotomy was performed in 28 patients diagnosed as having cervical zygapophyseal joint pain on the basis of controlled diagnostic blocks. Complete relief of pain was obtained in 71% of patients after an initial procedure. No patient who failed to respond to a first procedure responded to a repeat procedure, but if pain returned after a successful initial procedure, relief could be reinstated by a repeat procedure. The median duration of relief after a first procedure was 219 days when failures are included, but 422 days when only successful cases are considered. It was concluded that radiofrequency neurotomy provides clinically significant and satisfying periods of freedom from pain, and its effects can be reinstated if pain recurs.

## **5.5. INJECTIONS**

### **5.5.a) Intra-articular corticosteroid injection**

#### Conclusions of the QTF

A randomized controlled trial (Barnsley, 1994), examined the efficacy of intra-articular corticosteroid injection for relief of cervical zygapophyseal joint pain attributed to whiplash injury. The treatments compared were 0.5 percent bupivacaine (steroid) to 2 percent lidocaine (control). The pre-treatment characteristics of the steroid and anesthetic groups were similar, although median pain duration was slightly longer in the steroid than the control group. Pain relief for both treatments was brief. The duration of pain relief (time to return to 50% of baseline pain) did not differ significantly ( $p=0.42$ ) between steroid (median time 3 days) and local anesthetic (median time 3.5 days). The short duration of pain relief overall, and lack of efficacy between steroid and local anesthetic, leads to the conclusion that intra-articular steroid injection is not justified in treatment of cervical zygapophyseal joint pain after whiplash injury.

#### Update of the above conclusions by RAND Europe

No additional studies examining the efficacy of intra-articular corticosteroid injection for relief of cervical zygapophyseal joint pain attributed to whiplash injury were found.

### **5.5.b) Subcutaneous sterile water injection**

#### Conclusions of the QTF

A randomized trial (Byrn, 1993), examined the effectiveness of sterile water injection. The study, conducted in patients with chronic neck and shoulder pain 4 to 6 years after 'whiplash' injury, sterile water was injected at 5-80 trigger points, for up to 3 treatments in 2 months, in 20 patients. The control group received saline infiltration. The sterile water group had a greater improvement in reported pain at follow-up and in cervical ROM than the saline group. However, the QTF concluded that a major limitation of the study was the lack of blinding.

#### Update of the above conclusions by RAND Europe

No additional studies examining the effectiveness of sterile water injections were found.

### **5.5.c) Injections with botulinum toxin-A**

#### Conclusions of the QTF

This type of treatment is not mentioned in the literature review of the QTF.

#### Update of the above conclusions by RAND Europe

In a case series study, Freund *et al.* (1999) reported the effects of treatment of whiplash associated neck pain in eight patients with botulinum toxin-A. The 8 patients were assessed as chronic WAD II, in good health and had undergone extensive conservative therapy in the past with minimal success. Outcome measures included composite range of neck motion (ROM), subjective pain, and tenderness to palpation. All patients responded to the therapy with some improvement. The sample size was too small to test for significance. The positive results in the 8 cases suggest that improved ROM and pain relief can be obtained with pure and prolonged muscle relaxation.

### **5.5.d) Therapeutic zygapophyseal joint injections**

#### Conclusions of the QTF

This type of treatment is not mentioned in the literature review of the QTF.

#### Update of the above conclusions by RAND Europe

Slipman *et al.* (2001) performed a retrospective study with 18 patients who experienced persistent daily headache symptoms after a whiplash event which failed to improve after at least 3 months of physical therapy, activity restriction, and the use of oral analgesics. Each patient demonstrated initially a positive response to a diagnostic intra-articular C2-3 injection. Patients' symptom duration before diagnostic injection averaged 34 months. The patients were treated with fluoroscopically guided therapeutic intra-articular C2-3 zygapophyseal joint injections. Follow-up data collection transpired at an average of 19 months after the final therapeutic injection. In 61% of the patients, fewer than three headaches were experienced each week; these headaches were relieved with the use of oral analgesics. The authors conclude that, although the inherent limitations of the study preclude a definitive statement regarding the efficacy of C2-3 injections, the initial findings suggest that therapeutic intra-articular zygapophyseal joint injections are effective in the treatment of headaches emanating from the C2-3 joint after a whiplash event.

## **5.6. PHARMACOLOGIC INTERVENTIONS**

#### Conclusions of the QTF

The QTF concluded that no acceptable studies were found regarding the benefit of narcotic analgesics or psychopharmacologic therapeutics in WAD. Also, no acceptable studies were found regarding muscle relaxants in WAD.

#### Update of the above conclusions by RAND Europe

A prospective, randomized, double-blind study (Pettersson *et al.*, 1998) compared the efficacy of high-dose methylprednisolone administered within 8 hours after whiplash injury with placebo. Forty patients were included in the study; they were enrolled if their diagnoses were complete and treatment had begun within 8 hours after injury. To evaluate the effects of the treatment, Pettersson looked at: symptoms that were severe enough to prevent the patient from returning to work, number of sick days before and after the injury, and sick-leave profile after injury. At the follow-up examination 6 months after initial treatment, there was a significant difference in disabling symptoms between the actively treated patients and the placebo group ( $p=0.047$ ), total number of sick days

( $p=0.01$ ), and sick-leave profile ( $p=0.003$ ). It was concluded that acute treatment with high-dose methylprednisolone may be beneficial in preventing extensive sick leave after whiplash injury (but the number of patients studied was small).

Szpalski *et al.* (1994) conducted a controlled double-blind study to assess the effect of tenoxicam, an NSAID. 51 patients presenting with whiplash injuries less than 72 hours after the accident were included in the study. All were classified as groups I and II on the QTF scale. 25 patients were allocated to the tenoxicam group, and 26 to the placebo group. Pain and function were assessed on day 1 and 15. 2 patients, both in the tenoxicam group, were lost to follow-up. No patient presented with any side-effect leading to exclusion from the study. In terms of the VAS Pain Assessment, both groups showed a highly significant improvement during the study period. However, there appears to be a significant difference between the two treatments in favor of the NSAID. In terms of function assessment, both groups show a very significant improvement of function between day 1 and day 15. However, the results showed a significant difference in favor of the tenoxicam group for all variables except extension velocity and rotation acceleration.

## **5.7. PSYCHOSOCIAL INTERVENTIONS**

The QTF and RAND Europe did not accept any studies on psychosocial interventions in WAD.

## **5.8. MULTIDISCIPLINARY TREATMENT**

### Conclusions of the QTF

Analgesics (McKinney, 1989; Broding, 1984, mealy, 1986) and NSAIDS (Foley-Nolan, 1990, 1992) in combination with other treatment modalities were associated with short-term benefit for WAD 1 and 2 presenting in the acute phase or < 72 hours post collision.

### Update of the above conclusions by RAND Europe

A randomized controlled trial (Provinciali, 1996) assessed the long-term efficacy of a multi-modal rehabilitation approach on whiplash injury. 60 patients, recruited within two months after neck injury, were randomly allocated either to (A) an experimental multimodal treatment consisting of postural training, manual technique and psychological treatment, or (B) a control treatment using physical agents only such as electric and sonic modalities. Pain level, range of movement, self-rating scale of treatment efficacy and return-to-work delay were evaluated before and at the end of treatment, and later, 30 and 180 days after randomization. The benefit obtained with treatment A was greater and longer lasting than that experienced using B, despite the fact that the same benefit was obtained in joint mobility in the two groups. Patients undergoing the experimental treatment returned to their usual occupations sooner than the controls. It was concluded that the results seem to confirm the hypothesis of a multifactorial involvement as a possible mechanism for the late whiplash syndrome.

A descriptive study (Vendrig *et al.*, 2000) documents the improvements of patients with chronic symptoms after a whiplash injury who attended a 4-week multimodal treatment program at the RugAdviesCentra Nederland. 26 patients who experienced Quebec type 1 or 2 lesions of the neck with persisting symptoms of longer than 6 months' duration participated in the study. Outcomes were pain intensity, number of painful sites, self-reported disability, symptoms of somatic and psychological distress, cognitive symptoms, return to work, medication, and medical and paramedical treatment. The patient's symptoms improved significantly on nearly all self-report measures. The objective outcome criteria reported during the 6-month follow-up evaluation were: complete return to work (65%); complete or partial return to work (92%); no use of analgesics in the past 6 months (58%); and no medical or paramedical treatment in the past 6 months (81%). It was concluded that these early results indicated that a multimodal treatment program has the potential to be an effective treatment for patients with chronic symptoms after a whiplash injury.

## **5.9. OTHER INTERVENTIONS**

### **5.9.a) Prescribed function**

#### Conclusions of the QTF

Two randomized controlled trials (McKinney, 1989a, 1989b) were published regarding prescribed function in grade 1 and 2 WAD presenting within 72 hours of collision. These studies suggest that advice to mobilize, perform exercises, and to minimize inactivity and dependence on cervical collars and analgesics was at least as effective in improving ROM in the short term, and symptoms in the long term, as physiotherapy including McKenzie and Maitland mobilization.

#### Update of the above conclusions by RAND Europe

No additional studies were found.

### **5.9.b) Acupuncture**

#### Conclusions of the QTF

No research was found concerning acupuncture in WAD; there was one accepted study evaluating acupuncture in rheumatology outpatients with chronic neck pain. Patients were randomized to receive either acupuncture or sham transcutaneous nerve stimulation. At the final follow-up there were no statistically significant differences between the two groups. It should be noted that there were observed differences favoring acupuncture, that the statistical power of the study was limited due to small sample size, and that there were possible biases due to lack of blinding of subjects with regard to treatment and selection of subjects from a rheumatology practice.

#### Update of the above conclusions by RAND Europe

One study (Fattori, 1996) evaluated the postural changes after acupuncture treatment in a group of 15 patients with balance disorders caused by cervical torsion due to whiplash injury. The acupuncture treatment consisted of 3 sessions during which the acupuncture points Bladder 10 and Gall Bladder 20 were stimulated by means of piercing with needles, and manipulating the needles for 20 seconds. Each patient underwent posturographic evaluations before and just after each session of acupuncture. The tests were performed with open eyes (OE), closed eyes (CE), and closed eyes with retroflexed head (CER). The 17 patients in the control group were treated with drugs (FANS and myorelaxing) and physiotherapy only. The researchers observed a significant difference between the two groups regarding the reduction of the CER length of the statokinesigram just before each session of acupuncture and reduction of the frequency oscillations of the patients on the sagittal plane in the study group, in CER, whereas in the control group they observed a progressive increase in these values. It was concluded that the high percentage of positive results in our patients with whiplash injury leads to advocate the therapeutic efficacy of acupuncture for balance disorders due to cervical pathology, where it can be associated with or be a valid alternative to pharmacological treatment.

### **5.9.c) Magnetic necklace**

#### Conclusions of the QTF

There was one accepted study (Hong, 1982) regarding the efficacy of the magnetic necklace in chronic neck pain. Patients with neck and shoulder pain of more than one year duration were randomly assigned to active or sham magnetic necklace. Measurement at the baseline and after 3 weeks indicated no differences in reported pain or other outcomes between the two groups.

#### Update of the above conclusions by RAND Europe

No additional studies on efficacy of magnetic necklaces in whiplash patients were found.

## 6. CONCLUSIONS

### 6.1. INTRODUCTION

This chapter presents RAND Europe's analysis of the literature presented above. In this chapter we describe the conclusions we have drawn from the literature. These conclusions were not part of the literature review that was sent to the expert panels (see next chapter of this report). The main reason for this was that we wanted the experts to make their own judgment of the literature as the literature is not necessarily leading to unequivocal conclusions with respect to, for example, the effectiveness of a specific treatment for a specific whiplash patient.

In this chapter we consecutively present our findings with respect to the diagnostic techniques, prevalence of symptoms, prognostic factors, and treatment strategies. Finally, we will present some concluding remarks with respect to the state of the literature on WAD.

### 6.2. DIAGNOSTIC TECHNIQUES

In our literature review, we came across a wide range of techniques to diagnose WAD. Studies have been conducted on techniques, such as X-rays, MRIs, tomographies, bone scintigraphy, electromyography, and diagnostic z-joint blocks. In general, the quality of these articles was low. The inclusion of patients groups was often plagued by selection bias and often studies were conducted without use of control groups. It should therefore be concluded that none of the above diagnostic tests can currently be recommended to confirm a diagnosis of WAD.

### 6.3. PREVALENCE OF SYMPTOMS

After a whiplash injury, patients have reported a wide range of physical, cognitive, and psychological symptoms. Studies focusing on the prevalence of symptoms in whiplash patients have shown that neck pain and headache were most frequently reported. In addition, many other symptoms were reported, such as pain in shoulders and arms, dizziness, concentration problems, and visual disturbance. The studies included in the literature review show a wide range in the reported prevalence of symptoms, e.g. the reported prevalence of headache varies from 27% to 78% of whiplash patients.

### 6.4. PROGNOSTIC FACTORS

Several studies have been conducted to identify which factors contribute to the development of chronic WAD. The studied factors can be clustered in five categories, namely: (a) signs and symptoms; (b) radiological findings; (c) socio-demographic and economic factors; (d) psychological factors; and (e) crash-related factors.

Studies have identified many factors that, to a larger or lesser degree, contribute to development of chronic WAD. These factors include pre-trauma headache, initial injury-related reaction, female gender, higher age, psychological factors, and passenger status. The highest degree of predictability of development of chronic whiplash does not result from a single risk factor, but from a combination of several risk factors. A study by Radanov *et al.* (1996) showed that the following variables are in significant relationship with poor outcome at 1 year: impaired neck movement, history of pre-traumatic headache, history of head trauma, higher age, initial neck pain, initial headache intensity, nervousness score, neuroticism score and test score on focused attention. Employing these variables, correct prediction of outcome at 1 year was found in 88% of patients recruited from an insurance company, and in 96% of the primary care group. However, other studies give different results and no studies have shown complete predictability of development of chronic WAD.

## 6.5. TREATMENT STRATEGIES

The literature shows that a large variety of treatment strategies for WAD were studied. The main categories of treatment categories studied are: (a) immobilization; (b) activation; (c) passive modalities/electrotherapies; (d) injections; (e) surgical treatment; (f) pharmacological interventions; (g) psychological interventions; (h) multidisciplinary treatment; and (i) other interventions (e.g. acupuncture). For each of these treatment categories, we briefly describe what conclusions can be drawn from the literature.

- © **Immobilization:** The literature shows that immobilization, by prescribing rest or collars to immobilize the neck, is generally ineffective.
- © **Activation:** In general, it can be concluded from the literature that activation has beneficial effects over immobilization. The studies show some evidence for the effectiveness of physiotherapy and chiropractic treatment. There is no evidence, however, for the effectiveness of single manipulation.
- © **Passive modalities/electrotherapies:** In the literature review, we only accepted one study on the effectiveness of passive modalities/electrotherapies. This study showed there is no evidence for the effectiveness of pulsed electromagnetic treatment for whiplash patients.
- © **Injections:** Four studies on the effectiveness of injections for whiplash patients were accepted in the review. These provide some evidence that injections (injections with steroid water, injections with botulinum toxin-A, and intra-articular z-joint injections) might be beneficial for whiplash patients.
- © **Surgical treatment:** Four articles on percutaneous radiofrequency neurotomy, all by the same group of authors, were accepted in the literature review. These contain some evidence that percutaneous radiofrequency neurotomy can provide lasting relief of pain and psychological distress in patients with chronic z-joint pain.
- © **Pharmacological interventions:** The literature shows that there is some evidence for the effectiveness of high-dose methylprednisolone and tenoxicam in treatment of whiplash patients.
- © **Psychosocial interventions:** In our literature review, we did not accept any studies focusing on the effectiveness of psychosocial interventions.
- © **Multidisciplinary treatment:** We accepted two studies that suggest that a multimodal treatment program has the potential to be an effective treatment for patients with chronic symptoms after whiplash injury.
- © **Other interventions:** We accepted one study on other interventions, a study on acupuncture, in our literature review. The findings of this study advocate the therapeutic efficacy of acupuncture for balance disorders due to cervical pathology.

It can be concluded that there is no strong evidence for the effectiveness or ineffectiveness of specific treatment strategies for WAD, except maybe for activation which has shown to have beneficial effects over immobilization. For the effectiveness of other treatment strategies, such as injections, percutaneous radiofrequency neurotomy, pharmacological interventions, acupuncture and multidisciplinary treatment, there is only weak evidence that indicates that whiplash patients might benefit from these strategies.

## 6.6. CONCLUDING REMARKS

The evidence on diagnostic techniques, prognostic factors and effectiveness of treatments for WAD is generally very weak. This is a result of both the limited number of studies conducted on each of the individual prognostic factors and each of the individual treatment strategies, and the weak study designs of the study that have been conducted. Examples of weak study designs that we regularly came across were low numbers of included patients and uncontrolled studies.

It was striking that treatment studies gave little or no information on the characteristics of the patients included in the study. In those studies whiplash patients were generally handled as if they form a homogeneous group and react similarly to similar treatments. However, the literature on prognostic factors indicates that patient characteristics might have an effect on the probability that a patient develops chronic WAD. This means that it cannot be ruled out that some treatment strategies might be more appropriate for some patients and other strategies for others. The current study designs, unfortunately, make it impossible to relate patient characteristics to treatment outcomes, and therefore make it more difficult for caregivers to choose the appropriate treatment strategies for their patients.

The wide variety of studies related to WAD and the wide variety in the outcomes of these studies indicate the uncertainty related to WAD, and illustrate the heterogeneity of the syndrome.



## 7. BIBLIOGRAPHY (BY ALPHABET)

- Algers, G., K. Petterson, C. Hildingsson, and G. Toolanen, "Surgery for Chronic Symptoms after Whiplash Injury: Follow-up of 20 Cases", *Acta Orthopaedica Scandinavica*, Vol. 64, No.6, 1993, pp. 654-656.
- Antinnes, J.A., J. Dvorak, J. Hayek, M.M. Panjabi, and D. Grob, "The Value of Functional Computed Tomography in the Evaluation of Soft-Tissue Injury in the Upper Cervical Spine", *European Spine Journal*, Vol. 3, No. 2, 1994, pp. 98-101.
- Barnsley, L., S.M. Lord, B.J. Wallis, and N. Bogduk, "Lack of Effect of Intraarticular Corticosteroids for Chronic Pain in the Cervical Zygapophyseal Joints", *The New England Journal of Medicine*, Vol. 330, No. 15, 1994, pp. 1047-1050.
- Barnsley, L., S.M. Lord, and N. Bogduk, "Whiplash Injury", *Pain*, Vol. 58, No. 3, 1994, pp. 283-308.
- Barnsley, L., S.M. Lord, B.J. Wallis, and N. Bogduk, "The Prevalence of Chronic Cervical Zygapophyseal Joint Pain After Whiplash", *Spine*, Vol. 20, No. 1, 1995, pp. 20-26.
- Berglund, A., L. Alfredsson, J.D. Cassidy, I. Jensen, and A. Nygren, "The Association between Exposure to a Rear-End Collision and Future Neck or Shoulder Pain: A Cohort Study", *Journal of Clinical Epidemiology*, Vol. 53, No. 11, 2000, pp. 1089-1094.
- Bicik, I., B.P. Radanov, N. Schafer, J. Dvorak, B. Blum, B. Weber, C. Burger, G.K. von Schulthess, and A. Buck, "PET with 18 Fluorodeoxyglucose and Hexamethylpropylene Amine Oxime SPECT in Late Whiplash Syndrome", *Neurology*, Vol. 51, No. 2, 1998, pp. 345-350.
- Borchgrevink, G.E., O. Smevik, A. Nordby, P.A. Rinck, T.C. Stiles, and I. Lereim, "MR Imaging and Radiography of Patients with Cervical Hyperextension-Flexion Injuries after Car Accidents", *Acta Radiologica*, Vol. 36, 1995, pp. 425-428.
- Borchgrevink, G.E., I. Lereim, L. Røynealand, A. Bjørndal, and O. Haraldseth, "National Health Insurance Consumption and Chronic Symptoms Following Mild Neck Sprain Injuries in Car Collisions", *Scandinavian Journal of Social Medicine*, Vol. 4, 1996, pp. 264-271.
- Borchgrevink, G.E., T.C. Stiles, P.C. Borchgreving, and I. Lereim, "Personality Profile among Symptomatic and recovered Patients with Neck Sprain Injury, Measured by MCMI-I Acutely and 6 Months after Car Accidents", *Journal of Psychosomatic Research*, Vol. 42, No. 4, 1997, pp. 357-367. (1997a)
- Borchgrevink, G.E., O. Smevik, I. Haave, O. Haraldseth, A. Nordby, and I. Lereim, "MR Imaging of Cerebrum and Cervical Columna within Two Days after 'Whiplash' Neck Sprain Injury", *Injury*, Vol. 28, No. 5-6, 1997, pp. 331-335. (1997b)
- Borchgrevink, G.E., A. Kaasa, D. McDonagh, T.C. Stiles, O. Haraldseth, and I. Lereim, "Acute Treatment of Whiplash Neck Sprain Injuries: A Randomized Trial of Treatment during the First 14 days after a Car Accident", *Spine*, Vol. 23, No. 1, 1998, pp. 25-31.
- Brault, J.R., J.B. Wheeler, G.P. Siegmund, and E.J. Brault, "Clinical Response of Human Subjects to Rear-End Automobile Collisions", *Archives of Physiological and Medical Rehabilitation*, Vol. 79, No. 1, 1998, pp. 72-80.
- Bylund, P.O., and U. Björnstig, "Sick Leave and Disability Pension among Passenger Car Occupants Injured in Urban Traffic", *Spine*, Vol. 23, No. 9, 1998, pp. 1023-1028.
- Byrn, C., I. Olsson, L. Falkheden, M. Lindh, U. Hosterey, M. Fogelberg, L.E. Linder, and O. Bunketorp, "Subcutaneous Sterile Water Injections for Chronic Neck and Shoulder Pain Following Whiplash Injuries", *Lancet*, Vol. 341, No. 8843, 1993, pp. 449-452.
- Cassidy, J.D., L.J. Carroll, P. Cote, M. Lemstra, A. Berglund, and A. Nygren, "Effect of Eliminating Compensation for Pain and Suffering on the Outcome of Insurance Claims for Whiplash Injury", *New England Journal of Medicine*, Vol. 342., No. 16, 2000, pp. 1179-1186.

- Cote, P., J.D. Cassidy, and L. Carroll, "Is a Lifetime History of Neck Injury in a Traffic Collision Associated with Prevalent Neck Pain, Headache, and Depressive Symptomatology", *Accident Analysis and Prevention*, Vol. 32, No. 2, 2000, pp. 151-159.
- Cote, P., S. Hogg-Johnson, J.D. Cassidy, L. Carroll, and J.W. Frank, "The Association between Neck Pain Intensity, Physical Functioning, Depressive Symptomatology and Time-to-Closure after Whiplash", *Journal of Clinical Epidemiology*, Vol. 53, No. 3, 2001, pp. 275-286.
- Di Stefano, G., and B.P. Radanov, "Course of Attention and Memory after Common Whiplash: A Two-years Prospective Study with Age, Education, and Gender Pair-matched Patients", *Acta Neurologica Scandinavica*, Vol. 91, 1995, pp. 346-352.
- Dolinis, J., "Risk Factors for "Whiplash" in Drivers: A Cohort Study of Rear-end Traffic Crashes", *Injury*, Vol. 28, No. 3, 1997, pp. 173-179.
- Donk, J. van der, J.S. Schouten, J. Passchier, L.K. van Romunde, and H.A. Valkenburg, "The Associations of Neck Pain with Radiological Abnormalities of the Cervical Spine and Personality Traits in a General Population", *Journal of Rheumatology*, Vol. 18, No. 12, 1991, pp. 1884-1889.
- Fattori, B., C. Borsari, G. Vannucci, A. Casani, R. Christofani, L. Bonuccelli, and P.L. Ghilardi, "Acupuncture Treatment for Balance Disorders Following Whiplash Injury.", *Acupuncture and Electrotherapy Research*, Vol. 21, No. 3-4, 1996, pp. 207-217.
- Fitz-Ritson, D., "Phasic Exercises for Cervical Rehabilitation after "Whiplash" Trauma", *Journal of Manipulative and Physiological Therapy*, Vol. 18, No. 1, 1995, pp. 21-24.
- Foley-Nolan, D., K. Moore, M. Codd, C. Barry, P. O'Connor, and R.J. Coughlan, "Low Energy High Frequency Pulsed Electromagnetic Therapy for Acute Whiplash Injuries. A Double Blind Randomized Controlled Study.", *Scandinavian Journal of Rehabilitation Medicine*, Vol. 24., No. 1, 1992, pp. 51-59.
- Freund, B.J., and M. Schwartz, "Treatment of Whiplash Associated Neck Pain with Botulinum Toxin-A: report of 8 Cases", *Journal of Rheumatology*, Vol. 26, No.3, 1999, pp.756-758.
- Gargan, M., G. Bannister, C. Main, and S. Hollis, "The Behavioural Response to Whiplash Injury", *Journal of Bone Joint Surgery*, Vol. 79-B, No. 4, 1997, pp. 523-526.
- Gennis, P., L. Miller, E.J. Gallagher, J. Giglio, W. Carter, and N. Nathanson, "The Effect of Soft Cervical Collars on Persistent Neck Pain in Patients with Whiplash Injury", *Academic and Emergency Medicine*, Vol. 3, No. 6, 1996, pp. 563-564.
- Giebel, G.D., M. Edelmann, and R. Hüser, "Die Distorsion der Halswirbelsäule: Frühfunktionelle vs. Ruhigstellende Behandlung", *Zentralblatt für Chirurgie*, Vol. 122, 1997, pp. 517-521.
- Gimse R, I.A. Bjorgen, C. Tjell, J.S. Tyssedal, and K. Bo, " Reduced cognitive functions in a group of whiplash patients with demonstrated disturbances in the posture control system", *Journal of Clinical and Experimental Neuropsychology*, Vol. 19, No. 6, 1997, pp. 838-849.
- Hagström, Y., and J. Carlsson, "Prolonged Functional Impairments after Whiplash Injury", *Scandinavian Journal of Rehabilitation Medicine*, Vol 28, 1996, pp. 139-146.
- Harder, S., M. Veilleux, and S. Suissa, "The Effect of Socio-Demographic and Crash-Related Factors on the Prognosis of Whiplash", *Journal of Clinical Epidemiology*, Vol. 51, No. 5, 1998, pp. 377-384.
- Hartling, L., R.J. Brison, C. Arden, and W. Pickett, "Prognostic Value of the Quebec Classification of Whiplash-Associated Disorders", *Spine*, Vol. 26, No. 1, 2001, pp. 36-41.
- Jónsson, H., K. Cesarini, B. Sahlstedt, and W. Rauschnig, "Findings and Outcome in Whiplash-Type Neck Distortions", *Spine*, Vol. 19, No. 24, 1994, pp. 2733-2743.

- Karlsborg, M., A. Smed, H. Jespersen, S. Stephensen, M. Cortsen, P. Jennum, M. Herning, E. Korfitsen, and L. Werdelin, "A Prospective Study of 39 Patients with Whiplash Injury", *Acta Neurologica Scandinavica*, Vol. 95, 1997, pp. 65-72.
- Kessels, R.P.C., A. Keyser, W.I.M. Verhagen, and E.L.J.M. Luijtelaar, "The Whiplash Syndrome: A Psychophysiological and Neurophysiological Study towards Attention", *Acta Neurologica Scandinavica*, Vol. 97, 1998, pp. 188-193.
- Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Third Occipital Nerve Headache: A Prevalence Study", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 57, 1994, pp. 1187-1190.
- Lord, S.M., L. Barnsley, and N. Bogduk, "Percutaneous Radiofrequency Neurotomy in the Treatment of Cervical Zygapophyseal Joint Pain: A Caution", *Neurosurgery*, Vol. 366, No. 4, 1995, pp. 732-739.
- Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Chronic Cervical Zygapophyseal Joint Pain after Whiplash: A Placebo-Controlled Prevalence Study", *Spine*, Vol. 21, No. 15, 1996, pp. 1737-1745. (1996a)
- Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Percutaneous Radio-frequency Neurotomy for Chronic Cervical Zygapophyseal Joint Pain", *New England Journal of Medicine*, Vol. 335, No. 15, 1996, pp. 1721-1726. (1996b)
- Loudon, J.K., M. Ruhl, and E. Field, "Ability to Reproduce Head Position After Whiplash Injury", *Spine*, Vol. 22, No. 8, 1997, pp. 865-868.
- Magnusson, T., T. Ragnarsson, and A. Bjornsson, "Occipital Nerve Release in Patients with Whiplash Trauma and Occipital Neuralgia," *Headache*, Vol. 36, No. 1, 1996, pp. 32-36.
- Mallinson, A.I., and N.S. Longridge, "Specific Vocalized Complaints in Whiplash and Minor Head Injury Patients", *The American Journal of Otolaryngology*, Vol. 19, 1998, pp. 809-813. (1998a)
- Mallinson, A.I., and N.S. Longridge, "Dizziness from Whiplash and Head Injury: Differences between Whiplash and Head Injury", *The American Journal of Otolaryngology*, Vol. 19, 1998, pp. 814-818. (1998b)
- Mayou, R., and R. Bryant, "Outcome of 'Whiplash' Neck Injury", *Injury*, Vol. 27, No. 9, pp. 617-623.
- McDonald, G.J., S.M. Lord, and N. Bogduk, "Long-term Follow-up of Patients Treated with Cervical Radiofrequency Neurotomy for Chronic Neck Pain", *Neurosurgery*, Vol. 45, No. 1, 1999, pp. 61-68.
- McKinney, M.B., "Behandlung der HWS-Distorsionen bei sog-'Schleuderverletzungen'", *Orthopäde*, Vol. 23, 1994, pp. 287-290.
- Mosimann, U.P., R.M. Muri, J. Feblinger, and B.P. Radanov, "Saccadic Eye Movement Disturbances in Whiplash Patients with Persistent Complaints", *Brain*, Vol. 123, Pt. 4, 2000, pp. 828-835.
- Nederhand, M.J., M.J. IJzerman, H.J. Hermens, C.T. Baten, and G. Zilvold, "Cervical Muscle Dysfunction in the Chronic Whiplash Associated Disorder Grade II (WAD II)", *Spine*, Vol. 25, No. 15, 2000, pp. 1938-1943.
- Obelieniene, D., G. Bovim, H. Schrader, D. Surkiene, D. Mickeviciene, I. Miseviciene, and T. Sand, "Headache after Whiplash: A Historical Cohort Study outside the Medico-Legal Context", *Cephalalgia*, Vol. 18, 1998, pp. 559-564.
- Obelieniene, D., H. Schrader, G. Bovim, I. Miseviciene, and T. Sand, "Pain after Whiplash: A Prospective Controlled Inception Cohort Study", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 66, 1999, pp. 279-283.
- Osterbauer, P.J., K. Long, T.A. Ribaud, E.A. Petermann, A.W. Fuhr, S.J. Bigos, and G.T. Yamaguchi, "Three-Dimensional Head Kinematics and Cervical Range of Motion in the

- Diagnosis of Patients with Neck Trauma", *Journal of Manipulative and Physiological Therapy*, Vol. 19, No. 4, 1996, pp. 231-237.
- Otte, A., T.M. Ettl, L. Fierz, U. Kischka, J. Muerner, S. Hoegerle, P. Brautigam, and J. Muller-Brand, "Cerebral Findings Following Cervical Spine Distortion Caused by Acceleration Mechanism (Whiplash Injury): Assessment of Current Diagnostic Methods in Nuclear Medicine", *Schweiz Rundsch Med Prax*, Vol. 85, No. 36, pp. 1087-1090.
- Otte, A., T.M. Ettl, E.U. Nitzsche, K. Wachter, S. Hoegerle, G.H. Simon, L. Fierz, E. Moser, and J. Mueller-Brand, "PET and SPECT in Whiplash Syndrome: A New Approach to a Forgotten Brain", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 63, 1997, pp. 368-372.
- Partheni, M., C. Constantoyannis, R. Ferrari, G. Nikiforidis, S. Voulgaris, and N. Papadakis, "A Prospective Cohort Study of the Outcome of Acute Whiplash Injury in Greece", *Clinical and Experimental Rheumatology*, Vol. 18, 2000, pp. 67-70.
- Petterson, K., C. Hildingsson, G. Toolanen, M. Fagerlund, and J. Björnebrink, "MRI and Neurology in Acute Whiplash Trauma: No Correlation in Prospective Examination of 39 Cases", *Acta Orthopædica Scandinavica*, Vol. 65, No. 5, 1994, pp. 525-528.
- Petterson, K., J. Kärrholm, G. Toolanen, and C. Hildingsson, "Decreased Width of the Spinal Canal in Patients with Chronic Symptoms after Whiplash Injury", *Spine*, Vol. 20, No. 15, 1995, pp. 1664-1667.
- Petterson, K., C. Hildingsson, G. Toolanen, M. Fagerlund, and J. Björnebrink, "Disc Pathology after Whiplash Injury: A Prospective Magnetic Resonance Imaging and Clinical Investigation", *Spine*, Vol. 22, No. 3, 1997, pp. 283-288.
- Petterson, K., and G. Toolanen, "High-Dose Methylprednisolone Prevents Extensive Sick Leave after Whiplash Injury: A Prospective, Randomized, Double-Blind Study", *Spine*, Vol. 23, No. 9, 1998, pp. 984-989.
- Pfiffmann, Ch.W., Ch.A. Binkert, M. Zanetti, N. Boos, and J. Hodler, "Functional MR Imaging of the Craniocervical Junction. Correlation with Alar Ligaments and Occipito-Atlantoaxial Joint Morphology: A Study in 50 Asymptomatic Subjects", *Schweizerische Medizinische Wochenschrift*, Vol. 130, 2000, pp. 645-651.
- Pfiffmann, Ch.W., Ch.A. Binkert, M. Zanetti, N. Boos, and J. Hodler, "MR Morphology of Alar Ligaments and Occipito-Atlantoaxial Joints: Study in 50 Asymptomatic Subjects", *Radiology*, Vol. 218, 2001, pp. 133-137.
- Provinciali, L., M. Baroni, L. Illuminati, and M.G. Ceravolo, "Multimodal Treatment to Prevent the Late Whiplash Syndrome", *Scandinavian Journal of Rehabilitation Medicine*, Vol. 28, 1996, pp. 105-111.
- Radanov, B.P., I. Hirlinger, G. DiStefano, and L. Valach, "Attentional Processing in Cervical Spine Disorders", *Acta Neurologica Scandinavica*, Vol. 85, No. 5, 1992, pp. 358-262.
- Radanov, B.P., M. Sturzenegger, G. Di Stefano, A. Schnidrig, and M. Aljinovic, "Factors Influencing Recovery from headache after Common Whiplash", *British Medical Journal*, Vol. 307, No. 6905, 1993, pp. 652-655.
- Radanov, B.P., G. Di Stefano, A. Schnidrig, and M. Sturzenegger, "Common Whiplash: Psychosomatic or Somatopsychic?", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 57, 1994, pp. 486-490. (1994a)
- Radanov, B.P., M. Sturzenegger, G. Di Stefano, and A. Schnidrig, "Relationship between Early Somatic, Radiological, Cognitive and Psychosocial Findings and Outcome during a One-Year Follow-Up in 117 Patients Suffering from Common Whiplash", *British Journal of Rheumatology*, Vol. 33, 1994, pp. 442-448. (1994b)

- Radanov, B.P., M. Sturzenegger, and G. Di Stefano, "Long-Term Outcome after Whiplash Injury: A 2-Year Follow-Up Considering Features of Injury Mechanism and Somatic, Radiologic, and Psychosocial Findings", *Medicine*, Vol. 74, No. 5, 1995, pp. 281-297.
- Radanov, B.P., S. Begré, M. Sturzenegger, and K. Augustiny, "Course of Psychological Variables in Whiplash Injury - A 2-Year Follow-Up with Age, Gender and Education Pair-Matched Patients", *Pain*, Vol. 64, 1996, pp. 429-434. (1996a)
- Radanov, B.P., and J. Dvorak, "Impaired Cognitive Functioning After Whiplash Injury of the Cervical Spine", *Spine*, Vol. 21, No. 3, 1996, pp. 392-397. (1996b)
- Radanov, B.P., and M. Sturzenegger, "Predicting Recovery from Common Whiplash", *European Neurology*, Vol. 36, 1996, pp. 48-51. (1996c)
- Radanov, B.P., I. Bicik, J. Dvorak, J. Antinnes, G.K. von Schulthess, and A. Buck, "Relation between Neuropsychological and Neuroimaging Findings in Patients with Late Whiplash Syndrome", *Journal of Neurology, Neurosurgery and Psychiatry*, Vol. 66, No. 4, 1999, pp. 485-489.
- Richter, M., D. Otte, T. Pohlemann, C. Krettek, and M. Blauth, "Whiplash-Type Neck Distortions in Restrained Car Drivers: Frequency, Causes, and Long-Term Results", *European Spine Journal*, Vol. 9, No. 2, 2000, pp. 109-117.
- Ronnen, H.R., P.J. de Korte, P.R. Brink, H.J. van der Bijl, A.J. Tonino, and C.L. Franke, "Acute Whiplash Injury: Is there a Role for MR Imaging?: A Prospective Study of 100 Patients", *Radiology*, Vol. 201, No. 1, pp. 93-96.
- Rosenfeld, M., R. Gunnarsson, and P. Borenstein, "Early Intervention in Whiplash-Associated Disorders: A Comparison of Two Treatment Protocols", *Spine*, Vol. 25, No. 14, pp. 1782-1787.
- Satoh, S., S. Naito, T. Konishi, M. Yoshikawa, N. Morita, T. Okada, T. Kageyama, and I. Matsuzaki, "An Examination of Reasons for Prolonged Treatment in Japanese Patients with Whiplash Injuries", Vol. 5, No. 2, 1997, pp. 71-84.
- Schmand, B., J. Lindeboom, S. Schagen, R. Heijt, T. Koene, and H.L. Hamburger, "Cognitive Complaints in Patients after Whiplash Injury: The Impact of Malingering", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 64, 1998, pp. 339-343.
- Schrader, H., D. Obelieniene, G. Bovim, D. Surkiene, D. Mickeviciene, I. Miseviciene, and T. Sand, "Natural Evolution of Late Whiplash Syndrome outside the Medico-Legal Context", *The Lancet*, Vol. 347, 1996, pp. 1207- 1211.
- Senter for Medisinisk Metodevurdering, *Nakkeslengskade: Diagnostikk og evaluering: Metodevurdering basert på egen litteraturgransking*, Oslo, SMM-rapport Nr. 5/2000.
- Slipman, C.W., J.S. Lipetz, C.T. Plataras, H.B. Jackson, S.T. Yang, and A. M. Meyer, "Therapeutic Zygapophyseal Joint Injections for headaches Emanating from the C2-3 Joint", *American Journal of Physiological and Medical Rehabilitation*, Vol. 80, No. 3, 2001, pp. 182- 188.
- Smed, A., "Cognitive Function and Distress after Common Whiplash Injury", *Acta Neurologica Scandinavica*, Vol. 95, 1997, pp. 73-80.
- Soderlund, A., C. Olerud, and P. Lindberg, "Acute Whiplash-Associated Disorders (WAD): The Effects of Early Mobilization and Prognostic Factors in Long-Term Symptomatology", *Journal of Clinical Rehabilitation*, Vol. 14, No. 5, 2000, pp. 457-467.
- Spitzer, W.O., M.L. Skovron, L.R. Slami, J.D. Cassidy, J. Duranceau, S. Suissa, and E. Zeiss, "Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders: Redefining 'Whiplash' and its Management", *Spine*, Vol. 20, No. 8S, Supplement, 1995, p. 2S-73S.

- Squires, B., M.F. Gargan, and G.C. Bannister, "Soft-Tissue Injury of the Cervical Spine: 15-Year Follow-Up", *Journal of Bone and Joint Surgery*, Vol. 78-B, No. 6, 1996, pp. 955-957.
- Sturzenegger, M., G. Di Stefano, B.P. Radanov, and A. Schnidrig, "Presenting Symptoms and Signs after Whiplash Injury: The Influence of Accident Mechanisms", *Neurology*, Volume 44, 1994, pp. 688-693.
- Sturzenegger, M., B.P. Radanov, and G. Di Stefano, "The Effect of Accident Mechanisms and Initial Findings on the Long-Term Course of Whiplash Injury", *Journal of Neurology*, Vol. 242, 1995, pp. 443-449.
- Suissa, S., S. Harder, and M. Veilleux, "The Relation between Initial Symptoms and Signs and the Prognosis of Whiplash", *European Spine Journal*, Volume 10, 2001, pp. 44-49.
- Swartzman, L.C., R.W. Teasell, A.P. Shapiro, and A.J. McDermid, "The Effect of Litigation Status on Adjustment to Whiplash Injury", *Spine*, Vol. 21, No. 1, 1996, pp. 53-58.
- Swezey, R.L., A.M. Swezey, and K. Warner, "Efficacy of Home Cervical Traction", *American Journal of Physical and Medical Rehabilitation*, Vol. 78, No.1, 1999, pp. 30-32.
- Szpalski, M., and J.P. Hayez, "Objective Functional Assessment of the Efficacy of Tenoxicam in the Treatment of Acute Low Back Pain. A Double-Blind Placebo-Controlled Study", *British Journal of Rheumatology*, Vol. 33, No. 1, 1994, pp. 74-78.
- Verhagen, A.P., K. Lanser, R.A. de Bie, and H.C. de Vet, "Whiplash: Assessing the Validity of Diagnostic Tests in a Cervical Sensory Disturbance", *Journal of Manipulative and Physiological Therapy*, Vol. 19, No. 8, 1996, pp. 508-512.
- Versijpt, J., R.A. Dierckx, P. de Bondt, I. Dierckx, L. Lambrecht, and C. de Sadeleer, "The Contribution of Bone Scintigraphy in Occupational Health or Medical Insurance Claims: A Retrospective Study", *European Journal of Nuclear Medicine*, Vol. 26, No. 8, 1999, pp. 804-811.
- Voyvodic, F., J. Dolinis, V.M. Moore, G.A. Ryan, J.P. Slavotinek, A.M. Whyte, R.D. Hoile, and G.W. Taylor, "MRI of Car Occupants with Whiplash Injury", *Neuroradiology*, Vol. 39, 1997, pp. 35-40.
- Wallis, B.J., S.M. Lord, L. Barnsley, and N. Bogduk, "Pain and Psychologic Symptoms of Australian Patients with Whiplash", *Spine*, Vol. 21, No. 7, 1996, pp. 804-810.
- Wallis, B.J., S.M. Lord, and N. Bogduk, "Resolution of Psychological Distress of Whiplash Patients Following Treatment by Radiofrequency Neurotomy", *Pain*, Vol. 73, 1997, pp. 15-22.
- Wallis, B.J., S.M. Lord, L. Barnsley, and N. Bogduk, "The Psychological Profiles of Patients with Whiplash-Associated Headache", *Cephalalgia*, Vol. 18, 1998, pp. 101-105.
- Woodward, M.N., J.C.H. Cook, M.F. Gargan, and G.C. Bannister, "Chiropractic Treatment of Chronic 'Whiplash' Injuries", *Injury*, Vol. 27, No. 9, 1996, pp. 643-645.
- Wright, A., T.G. Mayer, and R. Gatchel, "Outcomes of Disabling Cervical Spine Disorders in Compensation Injuries: A Prospective Comparison to Tertiary Rehabilitation Response for Chronic Lumbar Spinal Disorders", *Spine*, Vol. 24, No. 2, 1999, pp. 178-183.
- Young, W.F., "The Enigma of Whiplash Injury: Current Management Strategies and Controversaries", *Postgraduate Medicine*, Vol. 109, No. 3, 2001, pp. 179-186.

## 8. BIBLIOGRAPHY (BY TOPIC)

### Diagnostic techniques

- Antinnes, J.A., J. Dvorak, J. Hayek, M.M. Panjabi, and D. Grob, "The Value of Functional Computed Tomography in the Evaluation of Soft-Tissue Injury in the Upper Cervical Spine", *European Spine Journal*, Vol. 3, No. 2, 1994, pp. 98-101.
- Bicik, I., B.P. Radanov, N. Schafer, J. Dvorak, B. Blum, B. Weber, C. Burger, G.K. von Schulthess, and A. Buck, "PET with 18 Fluorodeoxyglucose and Hexamethylpropylene Amine Oxime SPECT in Late Whiplash Syndrome", *Neurology*, Vol. 51, No. 2, 1998, pp. 345-350.
- Borchgrevink, G.E., O. Smevik, A. Nordby, P.A. Rinck, T.C. Stiles, and I. Lereim, "MR Imaging and Radiography of Patients with Cervical Hyperextension-Flexion Injuries after Car Accidents", *Acta Radiologica*, Vol. 36, 1995, pp. 425-428.
- Jónsson, H., K. Cesarini, B. Sahlstedt, and W. Rauschnig, "Findings and Outcome in Whiplash-Type Neck Distortions", *Spine*, Vol. 19, No. 24, 1994, pp. 2733-2743.
- Nederhand, M.J., M.J. IJzerman, H.J. Hermens, C.T. Baten, and G. Zilvold, "Cervical Muscle Dysfunction in the Chronic Whiplash Associated Disorder Grade II (WAD II)", *Spine*, Vol. 25, No. 15, 2000, pp. 1938-1943.
- Osterbauer, P.J., K. Long, T.A. Ribaud, E.A. Petermann, A.W. Fuhr, S.J. Bigos, and G.T. Yamaguchi, "Three-Dimensional Head Kinematics and Cervical Range of Motion in the Diagnosis of Patients with Neck Trauma", *Journal of Manipulative and Physiological Therapy*, Vol. 19, No. 4, 1996, pp. 231-237.
- Otte, A., T.M. Ettl, E.U. Nitzsche, K. Wachter, S. Hoegerle, G.H. Simon, L. Fierz, E. Moser, and J. Mueller-Brand, "PET and SPECT in Whiplash Syndrome: A New Approach to a Forgotten Brain", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 63, 1997, pp. 368-372.
- Otte, A., T.M. Ettl, L. Fierz, U. Kischka, J. Muerner, S. Hoegerle, P. Brautigam, and J. Muller-Brand, "Cerebral Findings Following Cervical Spine Distortion Caused by Acceleration Mechanism (Whiplash Injury): Assessment of Current Diagnostic Methods in Nuclear Medicine", *Schweiz Rundsch Med Prax*, Vol. 85, No. 36, pp. 1087-1090.
- Pettersson, K., C. Hildingsson, G. Toolanen, M. Fagerlund, and J. Björnebrink, "MRI and Neurology in Acute Whiplash Trauma: No Correlation in Prospective Examination of 39 Cases", *Acta Orthopædica Scandinavica*, Vol. 65, No. 5, 1994, pp. 525-528.
- Pfarrmann, Ch.W., Ch.A. Binkert, M. Zanetti, N. Boos, and J. Hodler, "Functional MR Imaging of the Craniocervical Junction. Correlation with Alar Ligaments and Occipito-Atlantoaxial Joint Morphology: A Study in 50 Asymptomatic Subjects", *Schweizerische Medizinische Wochenschrift*, Vol. 130, 2000, pp. 645-651.
- Pfarrmann, Ch.W., Ch.A. Binkert, M. Zanetti, N. Boos, and J. Hodler, "MR Morphology of Alar Ligaments and Occipito-Atlantoaxial Joints: Study in 50 Asymptomatic Subjects", *Radiology*, Vol. 218, 2001, pp. 133-137.
- Ronnen, H.R., P.J. de Korte, P.R. Brink, H.J. van der Bijl, A.J. Tonino, and C.L. Franke, "Acute Whiplash Injury: Is there a Role for MR Imaging?: A Prospective Study of 100 Patients", *Radiology*, Vol. 201, No. 1, pp. 93-96.
- Senter for Medisinsk Metodevurdering, *Nakkeslengskade: Diagnostikk og evaluering: Metodevurdering basert på egen litteraturgransking*, Oslo, SMM-rapport Nr. 5/2000.
- Verhagen, A.P., K. Lanser, R.A. de Bie, and H.C. de Vet, "Whiplash: Assessing the Validity of Diagnostic Tests in a Cervical Sensory Disturbance", *Journal of Manipulative and Physiological Therapy*, Vol. 19, No. 8, 1996, pp. 508-512.

Versijpt, J., R.A. Dierckx, P. de Bondt, I. Dierckx, L. Lambrecht, and C. de Sadeleer, "The Contribution of Bone Scintigraphy in Occupational Health or Medical Insurance Claims: A Retrospective Study", *European Journal of Nuclear Medicine*, Vol. 26, No. 8, 1999, pp. 804-811.

### **Prevalence of symptoms**

Borchgrevink, G.E., I. Lereim, L. Røynealand, A. Bjørndal, and O. Haraldseth, "National Health Insurance Consumption and Chronic Symptoms Following Mild Neck Sprain Injuries in Car Collisions", *Scandinavian Journal of Social Medicine*, Vol. 4, 1996, pp. 264-271.

Bylund, P.O., and U. Björnstig, "Sick Leave and Disability Pension among Passenger Car Occupants Injured in Urban Traffic", *Spine*, Vol. 23, No. 9, 1998, pp. 1023-1028.

Di Stefano, G., and B.P. Radanov, "Course of Attention and Memory after Common Whiplash: A Two-years Prospective Study with Age, Education, and Gender Pair-matched Patients", *Acta Neurologica Scandinavica*, Vol. 91, 1995, pp. 346-352.

Gimse R, I.A. Bjorgen, C. Tjell, J.S. Tyssedal, and K. Bo, "Reduced cognitive functions in a group of whiplash patients with demonstrated disturbances in the posture control system", *Journal of Clinical and Experimental Neuropsychology*, Vol. 19, No. 6, 1997, pp. 838-849.

Hagström, Y., and J. Carlsson, "Prolonged Functional Impairments after Whiplash Injury", *Scandinavian Journal of Rehabilitation Medicine*, Vol. 28, 1996, pp. 139-146.

Kessels, R.P.C., A. Keyser, W.I.M. Verhagen, and E.L.J.M. Luijtelaar, "The Whiplash Syndrome: A Psychophysiological and Neurophysiological Study towards Attention", *Acta Neurologica Scandinavica*, Vol. 97, 1998, pp. 188-193.

Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Third Occipital Nerve Headache: A Prevalence Study", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 57, 1994, pp. 1187-1190.

Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Chronic Cervical Zygapophyseal Joint Pain after Whiplash: A Placebo-Controlled Prevalence Study", *Spine*, Vol. 21, No. 15, 1996, pp. 1737-1745. (1996a)

Mallinson, A.I., and N.S. Longridge, "Specific Vocalized Complaints in Whiplash and Minor Head Injury Patients", *The American Journal of Otolaryngology*, Vol. 19, 1998, pp. 809-813. (1998a)

Mallinson, A.I., and N.S. Longridge, "Dizziness from Whiplash and Head Injury: Differences between Whiplash and Head Injury", *The American Journal of Otolaryngology*, Vol. 19, 1998, pp. 814-818. (1998b)

Mosimann, U.P., R.M. Muri, J. Feblinger, and B.P. Radanov, "Saccadic Eye Movement Disturbances in Whiplash Patients with Persistent Complaints", *Brain*, Vol. 123, Pt. 4, 2000, pp. 828-835.

Partheni, M., C. Constantoyannis, R. Ferrari, G. Nikiforidis, S. Voulgaris, and N. Papadakis, "A Prospective Cohort Study of the Outcome of Acute Whiplash Injury in Greece", *Clinical and Experimental Rheumatology*, Vol. 18, 2000, pp. 67-70.

Richter, M., D. Otte, T. Pohlemann, C. Krettek, and M. Blauth, "Whiplash-Type Neck Distortions in Restrained Car Drivers: Frequency, Causes, and Long-Term Results", *European Spine Journal*, Vol. 9, No. 2, 2000, pp. 109-117.

Schmand, B., J. Lindeboom, S. Schagen, R. Heijl, T. Koene, and H.L. Hamburger, "Cognitive Complaints in Patients after Whiplash Injury: The Impact of Malingering", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 64, 1998, pp. 339-343.

Schrader, H., D. Obelieniene, G. Bovim, D. Surkiene, D. Mickeviciene, I. Miseviciene, and T. Sand, "Natural Evolution of Late Whiplash Syndrome outside the Medico-Legal Context", *The Lancet*, Vol. 347, 1996, pp. 1207-1211.



- Smed, A., "Cognitive Function and Distress after Common Whiplash Injury", *Acta Neurologica Scandinavica*, Vol. 95, 1997, pp. 73-80.
- Squires, B., M.F. Gargan, and G.C. Bannister, "Soft-Tissue Injury of the Cervical Spine: 15-Year Follow-Up", *Journal of Bone and Joint Surgery*, Vol. 78-B, No. 6, 1996, pp. 955-957.
- Wallis, B.J., S.M. Lord, L. Barnsley, and N. Bogduk, "Pain and Psychologic Symptoms of Australian Patients with Whiplash", *Spine*, Vol. 21, No. 7, 1996, pp. 804-810.
- Wallis, B.J., S.M. Lord, L. Barnsley, and N. Bogduk, "The Psychological Profiles of Patients with Whiplash-Associated Headache", *Cephalalgia*, Vol. 18, 1998, pp. 101-105.

### **Prognostic factors - signs and symptoms**

- Dolinis, J., "Risk Factors for "Whiplash" in Drivers: A Cohort Study of Rear-end Traffic Crashes", *Injury*, Vol. 28, No. 3, 1997, pp. 173-179.
- Gargan, M., G. Bannister, C. Main, and S. Hollis, "The Behavioural Response to Whiplash Injury", *Journal of Bone joint Surgery*, Vol. 79-B, No. 4, 1997, pp. 523-526.
- Hartling, L., R.J. Brison, C. Ardern, and W. Pickett, "Prognostic Value of the Quebec Classification of Whiplash-Associated Disorders", *Spine*, Vol. 26, No. 1, 2001, pp. 36-41.
- Loudon, J.K., M. Ruhl, and E. Field, "Ability to Reproduce Head Position After Whiplash Injury", *Spine*, Vol. 22, No. 8, 1997, pp. 865-868.
- Mayou, R., and R. Bryant, "Outcome of 'Whiplash' Neck Injury", *Injury*, Vol. 27, No. 9, pp. 617-623.
- Obelieniene, D., H. Schrader, G. Bovim, I. Miseviciene, and T. Sand, "Pain after Whiplash: A Prospective Controlled Inception Cohort Study", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 66, 1999, pp. 279-283.
- Obelieniene, D., G. Bovim, H. Schrader, D. Surkiene, D. Mickeviciene, I. Miseviciene, and T. Sand, "Headache after Whiplash: A Historical Cohort Study outside the Medico-Legal Context", *Cephalalgia*, Vol. 18, 1998, pp. 559-564.
- Petterson, K., J. Kärrholm, G. Toolanen, and C. Hildingsson, "Decreased Width of the Spinal Canal in Patients with Chronic Symptoms after Whiplash Injury", *Spine*, Vol. 20, No. 15, 1995, pp. 1664-1667.
- Radanov, B.P., M. Sturzenegger, G. Di Stefano, A. Schnidrig, and M. Aljinovic, "Factors Influencing Recovery from Headache after Common Whiplash", *British Medical Journal*, Vol. 307. No. 6905, 1993, pp. 652-655.
- Radanov, B.P., G. Di Stefano, A. Schnidrig, and M. Sturzenegger, "Common Whiplash: Psychosomatic or Somatopsychic?", *Journal of Neurology, Neurosurgery, and Psychiatry*, Vol. 57, 1994, pp. 486-490. (1994a)
- Radanov, B.P., M. Sturzenegger, G. Di Stefano, and A. Schnidrig, "Relationship between Early Somatic, Radiological, Cognitive and Psychosocial Findings and Outcome during a One-Year Follow-Up in 117 Patients Suffering from Common Whiplash", *British Journal of Rheumatology*, Vol. 33, 1994, pp. 442-448. (1994b)
- Radanov, B.P., M. Sturzenegger, and G. Di Stefano, "Long-Term Outcome after Whiplash Injury: A 2-Year Follow-Up Considering Features of Injury Mechanism and Somatic, Radiologic, and Psychosocial Findings", *Medicine*, Vol. 74, No. 5, 1995, pp. 281-297.
- Radanov, B.P., and M. Sturzenegger, "Predicting Recovery from Common Whiplash", *European Neurology*, Vol. 36, 1996, pp. 48-51. (1996c)
- Satoh, S., S. Naito, T. Konishi, M. Yoshikawa, N. Morita, T. Okada, T. Kageyama, and I. Matsuzaki, "An Examination of Reasons for Prolonged Treatment in Japanese Patients with Whiplash Injuries", Vol. 5, No. 2, 1997, pp. 71-84.

Schrader, H., D. Obelieniene, G. Bovim, D. Surkiene, D. Mickeviciene, I. Miseviciene, and T. Sand, "Natural Evolution of Late Whiplash Syndrome outside the Medico-Legal Context", *The Lancet*, Vol. 347, 1996, pp. 1207- 1211.

Suissa, S., S. Harder, and M. Veilleux, "The Relation between Initial Symptoms and Signs and the Prognosis of Whiplash", *European Spine Journal*, Volume 10, 2001, pp. 44-49.

#### **Prognostic factors - radiological findings**

Borchgrevink, G.E., O. Smevik, I. Haave, O. Haraldseth, A. Nordby, and I. Lereim, "MR Imaging of Cerebrum and Cervical Columna within Two Days after 'Whiplash' Neck Sprain Injury", *Injury*, Vol. 28. No. 5-6, 1997, pp. 331-335. (1997b)

Donk, J. van der, J.S. Schouten, J. Passchier, L.K. van Romunde, and H.A. Valkenburg, "The Associations of Neck Pain with Radiological Abnormalities of the Cervical Spine and Personality Traits in a General Population", *Journal of Rheumatology*, Vol. 18, No. 12, 1991, pp. 1884-1889.

Petterson, K., C. Hildingsson, G. Toolanen, M. Fagerlund, and J. Björnebrink, "Disc Pathology after Whiplash Injury: A Prospective Magnetic Resonance Imaging and Clinical Investigation", *Spine*, Vol. 22, No. 3, 1997, pp. 283-288.

Voyvodic, F., J. Dolinis, V.M. Moore, G.A. Ryan, J.P. Slavotinek, A.M. Whyte, R.D. Hoile, and G.W. Taylor, "MRI of Car Occupants with Whiplash Injury", *Neuroradiology*, Vol. 39, 1997, pp. 35-40.

#### **Prognostic factors - socio-demographic and economic factors**

Brault, J.R., J.B. Wheeler, G.P. Siegmund, and E.J. Brault, "Clinical Response of Human Subjects to Rear-End Automobile Collisions", *Archives of Physiological and Medical Rehabilitation*, Vol. 79, No. 1, 1998, pp. 72-80.

Cassidy, J.D., L.J. Carroll, P. Cote, M. Lemstra, A. Berglund, and A. Nygren, "Effect of Eliminating Compensation for Pain and Suffering on the Outcome of Insurance Claims for Whiplash Injury", *New England Journal of Medicine*, Vol. 342., No. 16, 2000, pp. 1179-1186.

Cote, P., S. Hogg-Johnson, J.D. Cassidy, L. Carroll, and J.W. Frank, "The Association between Neck Pain Intensity, Physical Functioning, Depressive Symptomatology and Time-to-Closure after Whiplash", *Journal of Clinical Epidemiology*, Vol. 53, No. 3, 2001, pp. 275-286.

Dolinis, J., "Risk Factors for "Whiplash" in Drivers: A Cohort Study of Rear-end Traffic Crashes", *Injury*, Vol. 28, No. 3, 1997, pp. 173-179.

Harder, S., M. Veilleux, and S. Suissa, "The Effect of Socio-Demographic and Crash-Related Factors on the Prognosis of Whiplash", *Journal of Clinical Epidemiology*, Vol. 51, No. 5, 1998, pp. 377-384.

Swartzman, L.C., R.W. Teasell, A.P. Shapiro, and A.J. McDermid, "The Effect of Litigation Status on Adjustment to Whiplash Injury", *Spine*, Vol. 21, No. 1, 1996, pp. 53-58.

Wright, A., T.G. Mayer, and R. Gatchel, "Outcomes of Disabling Cervical Spine Disorders in Compensation Injuries: A Prospective Comparison to Tertiary Rehabilitation Response for Chronic Lumbar Spinal Disorders", *Spine*, Vol. 24, No. 2, 1999, pp. 178-183.

#### **Prognostic factors - psychological factors**

Borchgrevink, G.E., T.C. Stiles, P.C. Borchgrevink, and I. Lereim, "Personality Profile among Symptomatic and recovered Patients with Neck Sprain Injury, Measured by MCMI-I Acutely

and 6 Months after Car Accidents, *Journal of Psychosomatic Research*, Vol. 42, No. 4, 1997, pp. 357-367. (1997a)

Cote, P., J.D. Cassidy, and L. Carroll, "Is a Lifetime History of Neck Injury in a Traffic Collision Associated with Prevalent Neck Pain, Headache, and Depressive Symptomatology", *Accident Analysis and Prevention*, Vol. 32, No. 2, 2000, pp. 151-159.

Karlsborg, M., A. Smed, H. Jespersen, S. Stephensen, M. Cortsen, P. Jennum, M. Herning, E. Korfitsen, and L. Werdelin, "A Prospective Study of 39 Patients with Whiplash Injury", *Acta Neurologica Scandinavica*, Vol. 95, 1997, pp. 65-72.

Radanov, B.P., S. Bégré, M. Sturzenegger, and K. Augustiny, "Course of Psychological Variables in Whiplash Injury - A 2-Year Follow-Up with Age, Gender and Education Pair-Matched Patients", *Pain*, Vol. 64, 1996, pp. 429-434. (1996a)

### **Prognostic factors - crash-related factors**

Berglund, A., L. Alfredsson, J.D. Cassidy, I. Jensen, and A. Nygren, "The Association between Exposure to a Rear-End Collision and Future Neck or Shoulder Pain: A Cohort Study", *Journal of Clinical Epidemiology*, Vol. 53, No. 11, 2000, pp. 1089-1094.

Harder, S., M. Veilleux, and S. Suissa, "The Effect of Socio-Demographic and Crash-Related Factors on the Prognosis of Whiplash", *Journal of Clinical Epidemiology*, Vol. 51, No. 5, 1998, pp. 377-384.

Sturzenegger, M., G. Di Stefano, B.P. Radanov, and A. Schnidrig, "Presenting Symptoms and Signs after Whiplash Injury: The Influence of Accident Mechanisms", *Neurology*, Volume 44, 1994, pp. 688-693.

Sturzenegger, M., B.P. Radanov, and G. Di Stefano, "The Effect of Accident Mechanisms and Initial Findings on the Long-Term Course of Whiplash Injury", *Journal of Neurology*, Vol. 242, 1995, pp. 443-449.

### **Treatment strategies - immobilization**

Borchgrevink, G.E., A. Kaasa, D. McDonagh, T.C. Stiles, O. Haraldseth, and I. Lereim, "Acute Treatment of Whiplash Neck Sprain Injuries: A Randomized Trial of Treatment during the First 14 Days after a Car Accident", *Spine*, Vol. 23, No. 1, 1998, pp. 25-31.

Gennis, P., L. Miller, E.J. Gallagher, J. Giglio, W. Carter, and N. Nathanson, "The Effect of Soft Cervical Collars on Persistent Neck Pain in Patients with Whiplash Injury", *Academic and Emergency Medicine*, Vol. 3, No. 6, 1996, pp. 563-564.

Giebel, G.D., M. Edelmann, and R. Hüser, "Die Distorsion der Halswirbelsäule: Frühfunktionelle vs. Ruhigstellende Behandlung", *Zentralblatt für Chirurgie*, Vol. 122, 1997, pp. 517-521.

### **Treatment strategies - activation**

Fitz-Ritson, D., "Phasic Exercises for Cervical Rehabilitation after "Whiplash" Trauma", *Journal of Manipulative and Physiological Therapy*, Vol. 18, No. 1, 1995, pp. 21-24.

McKinney, M.B., "Behandlung der HWS-Distorsionen bei sog-'Schleuderverletzungen'", *Orthopäde*, Vol. 23, 1994, pp. 287-290.

Rosenfeld, M., R. Gunnarsson, and P. Borenstein, "Early Intervention in Whiplash-Associated Disorders: A Comparison of Two Treatment Protocols", *Spine*, Vol. 25, No. 14, pp. 1782-1787.

- Soderlund, A., C. Olerud, and P. Lindberg, "Acute Whiplash-Associated Disorders (WAD): The Effects of Early Mobilization and Prognostic Factors in Long-Term Symptomatology", *Journal of Clinical Rehabilitation*, Vol. 14, No. 5, 2000, pp. 457-467.
- Swezey, R.L., A.M. Swezey, and K. Warner, "Efficacy of Home Cervical Traction", *American Journal of Physical and Medical Rehabilitation*, Vol. 78, No.1, 1999, pp. 30-32.
- Woodward, M.N., J.C.H. Cook, M.F. Gargan, and G.C. Bannister, "Chiropractic Treatment of Chronic 'Whiplash' Injuries", *Injury*, Vol. 27, No. 9, 1996, pp. 643-645.

#### **Treatment strategies - passive modalities/electrotherapies**

- Foley-Nolan, D., K. Moore, M. Codd, C. Barry, P. O'Connor, and R.J. Coughlan, "Low Energy High Frequency Pulsed Electromagnetic Therapy for Acute Whiplash Injuries. A Double Blind Randomized Controlled Study.", *Scandinavian Journal of Rehabilitation Medicine*, Vol. 24., No. 1, 1992, pp. 51-59.

#### **Treatment strategies - surgical treatment**

- Algers, G., K. Petterson, C. Hildingsson, and G. Toolanen, "Surgery for Chronic Symptoms after Whiplash Injury: Follow-up of 20 Cases", *Acta Orthopaedica Scandinavica*, Vol. 64, No.6, 1993, pp. 654-656.
- Lord, S.M., L. Barnsley, and N. Bogduk, "Percutaneous Radiofrequency Neurotomy in the Treatment of Cervical Zygapophyseal Joint Pain: A Caution", *Neurosurgery*, Vol. 366, No. 4, 1995, pp. 732-739.
- Lord, S.M., L. Barnsley, B.J. Wallis, and N. Bogduk, "Percutaneous Radio-frequency Neurotomy for Chronic Cervical Zygapophyseal Joint Pain", *New England Journal of Medicine*, Vol. 335, No. 15, 1996, pp. 1721-1726 (1996b).
- Magnusson, T., T. Ragnarsson, and A. Bjornsson, "Occipital Nerve Release in Patients with Whiplash Trauma and Occipital Neuralgia," *Headache*, Vol. 36, No. 1, 1996, pp. 32-36.
- McDonald, G.J., S.M. Lord, and N. Bogduk, "Long-term Follow-up of Patients Treated with Cervical Radiofrequency Neurotomy for Chronic Neck Pain", *Neurosurgery*, Vol. 45, No. 1, 1999, pp. 61-68.
- Wallis, B.J., S.M. Lord, and N. Bogduk, "Resolution of Psychological Distress of Whiplash Patients Following Treatment by Radiofrequency Neurotomy", *Pain*, Vol. 73, 1997, pp. 15-22.

#### **Treatment strategies - injections**

- Barnsley, L., S.M. Lord, B.J. Wallis, and N. Bogduk, "Lack of Effect of Intraarticular Corticosteroids for Chronic Pain in the Cervical Zygapophyseal Joints", *The New England Journal of Medicine*, Vol. 330, No. 15, 1994, pp. 1047-1050.
- Barnsley, L., S.M. Lord, B.J. Wallis, and N. Bogduk, "The Prevalence of Chronic Cervical Zygapophyseal Joint Pain After Whiplash", *Spine*, Vol. 20, No. 1, 1995, pp. 20-26.
- Byrn, C., I. Olsson, L. Falkheden, M. Lindh, U. Hosterey, M. Fogelberg, L.E. Linder, and O. Bunketorp, "Subcutaneous Sterile Water Injections for Chronic Neck and Shoulder Pain Following Whiplash Injuries", *Lancet*, Vol. 341, No. 8843, 1993, pp. 449-452.
- Freund, B.J., and M. Schwartz, "Treatment of Whiplash Associated Neck Pain with Botulinum Toxin-A: report of 8 Cases", *Journal of Rheumatology*, Vol. 26, No.3, 1999, pp.756-758.

Slipman, C.W., J.S. Lipetz, C.T. Plataras, H.B. Jackson, S.T. Yang, and A. M. Meyer, "Therapeutic Zygapophyseal Joint Injections for headaches Emanating from the C2-3 Joint", *American Journal of Physiological and Medical Rehabilitation*, Vol. 80, No. 3, 2001, pp. 182- 188.

#### **Treatment strategies - pharmacologic interventions**

Petterson, K., and G. Toolanen, "High-Dose Methylprednisolone Prevents Extensive Sick Leave after Whiplash Injury: A Prospective, Randomized, Double-Blind Study", *Spine*, Vol. 23, No. 9, 1998, pp. 984-989.

Szpalski, M., and J.P. Hayez, "Objective Functional Assessment of the Efficacy of Tenoxicam in the Treatment of Acute Low Back Pain. A Double-Blind Placebo-Controlled Study", *British Journal of Rheumatology*, Vol. 33, No. 1, 1994, pp. 74-78.

#### **Treatment strategies - psychosocial interventions**

No articles accepted.

#### **Treatment strategies - multidisciplinary treatment**

Provinciali, L., M. Baroni, L. Illuminati, and M.G. Ceravolo, "Multimodal Treatment to Prevent the Late Whiplash Syndrome", *Scandinavian Journal of Rehabilitation Medicine*, Vol. 28, 1996, pp. 105-111.

#### **Treatment strategies - other interventions**

Fattori, B., C. Borsari, G. Vannucci, A. Casani, R. Christofani, L. Bonuccelli, and P.L. Ghilardi, "Acupuncture Treatment for Balance Disorders Following Whiplash Injury.", *Acupuncture and Electrotherapy Research*, Vol. 21, No. 3-4, 1996, pp. 207-217.

#### **General articles (covering several different topics)**

Barnsley, L., S.M. Lord, and N. Bogduk, "Whiplash Injury", *Pain*, Vol. 58, No. 3, 1994, pp. 283-308.

Radanov, B.P., and J. Dvorak, "Impaired Cognitive Functioning After Whiplash Injury of the Cervical Spine", *Spine*, Vol. 21, No. 3, 1996, pp. 392-397. (1996b)

Radanov, B.P., I. Bick, J. Dvorak, J. Antinnes, G.K. von Schulthess, and A. Buck, "Relation between Neuropsychological and Neuroimaging Findings in Patients with Late Whiplash Syndrome", *Journal of Neurology, Neurosurgery and Psychiatry*, Vol. 66, No. 4, 1999, pp. 485-489.

Spitzer, W.O., M.L. Skovron, L.R. Slami, J.D. Cassidy, J. Duranceau, S. Suissa, and E. Zeiss, "Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders: Redefining 'Whiplash' and its Management", *Spine*, Vol. 20, No. 8S, Supplement, 1995, p. 2S-73S.

Young, W.F., "The Enigma of Whiplash Injury: Current Management Strategies and Controversaries", *Postgraduate Medicine*, Vol. 109, No. 3, 2001, pp. 179-186.

**APPENDIX A: SUMMARY TABLE ON PROGNOSTIC FACTORS**

<b>First author</b>	<b>Year of publication</b>	<b>Type of study</b>	<b>Number of patients</b>	<b>Description of patient population</b>	<b>Time of assessment</b>	<b>Factors that are associated with the development of a chronic whiplash</b>	<b>Factors that are not associated with the development of a chronic whiplash</b>
Radanov	1991	Prospective cohort study	78	Patients who attended primary care practices within 7 days of a whiplash injury.	6 months after injury	Finger paresthesia.	
Radanov	1993	Prospective cohort study	117	Patients who had recent common whiplash	3 and 6 months injury	Pre-trauma headache and neck pain associated with a delay in recovery from trauma-related headache.	
Norris	1983	Cohort study	61	Patients with neck injury resulting from a motor vehicle accident	6 months after injury	Presence of musculoskeletal or neurologic signs within 3 days of MVC.	
Radanov	1994b	Prospective cohort study	117	Patients who had recent common whiplash	3, 6, and 12 months	Poor recovery is related to severity of injury in addition to some pre-traumatic factors (previous history of head trauma and headache) and initial injury-related reaction (i.e. sleep disturbances, reduced speed of information processing and nervousness).	Psychosocial factors did not prove predictive at any follow-up examination.
Petterson	1995	Prospective cohort study	48	Whiplash patients with acute whiplash injury after car accidents.	12 months after injury	Spinal canal width was significantly smaller in patients with persistent symptoms than in the asymptomatic group. A	

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
						significant difference was also found between men and women.	
Mayou	1995	Prospective cohort study	74	Whiplash patients	1 year	For physical symptoms: report of neck symptoms immediately after the accident, female gender, and passenger status. For mental state: high neuroticism score, and history of consultation for psychological problems before the accident. For social outcome: psychological factors.	No clear differences in physical or psychological outcome between those who were claimants and those who were not, and between those who settled early and those who settled late.
Radanov	1996	1-year prospective cohort study	133 (Group I: 117; Group 2: 16)	Group I: whiplash patients referred from primary care. Group II: whiplash patients referred from an insurance company.	1 year	Impaired neck movement, history of pre-traumatic headache, history of head trauma, higher age, initial neck pain, initial headache intensity, nervousness score, neuroticism score, and test score on focused attention.	
Schrader	1996	Retrospective questionnaire based cohort study	Group I: 202	Group I: Lithuanians who have experienced a rear-end collision; Group II: A sex- and age-matched control group of	1-3 years		No significant difference between the 2 groups was found. A family history of neck pain was the most important risk factor for

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
				uninjured individuals.			current neck symptoms. It was concluded that expectation of disability, a family history, and pre-existing symptoms to the trauma may be more important determinants for the evolution of the late whiplash syndrome.
Obelieniene	1999	Prospective controlled cohort study	Group I: 210	Group I: Lithuanians recently exposed to a rear-end collision; Group II: control group	1 year		No significant differences between the two groups were found concerning frequency and intensity of symptoms.
Dolinis	1997	Retrospective cohort study	246	Car drivers with recent experience of rear-impact (Adelaide Metropolitan area)		Significant: A history of neck pain and female sex. Not significant, but an increased risk: light vehicles and not being aware of the impending collision.	Driver's occupation or level of education.
Gargan	1997	Prospective cohort study	50	Consecutive patients presenting at an accident department after rear-end vehicle collisions.	1 week, 3 months, 2 years	Clinical outcome after 2 years could be predicted at 3 months by neck stiffness (76% accuracy), and psychological score (74% accuracy).	
Satoh	1997	Prospective cohort study	3167	Patients with whiplash injuries who had been in rear-end	6 months	Female gender, use of emergency vehicle transpor-	Employment status



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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
				collisions and who continued to elicit treatment-receiving behavior at 1.5, 3 and 6 months post-trauma.		tation, and early complaint of symptoms.	
Suissa	2001	Population-based incident cohort study	2627	Individuals who sustained a whiplash injury resulting from a MVC in Quebec in 1987.	Patients were followed for 7 years.	Female gender, older age, neck pain on palpation, muscle pain, pain or numbness radiating from the neck to arms, hands or shoulders, and headache.	
Hartling	2001	Retrospective cohort study	380	Patients categorized according to the Quebec Classification based on signs and symptoms documented in their emergency medical chart.	6, 12, 18, and 24 months post-collision	Classification was prognostic in that risk for WAD at 6, 12, 18, and 24 months increased with increasing grade. The greatest risk for long-term symptoms was seen among the group of patients with both point tenderness and limited range of motion.	
Borchgrevink	1997	Prospective cohort study	60 (Group I: 40; Group II: 20)	Group I: Neck sprain patients with whiplash injury mechanism after car accident. Group II: control group of volunteers.	Within 2 days after accident; repeated after 2 weeks, 6 weeks, 3 months and 6 months.		MRI within 2 days after MVC could not detect pathology connected to the injury nor further predict symptom development and outcome.

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
Petterson	1997	Prospective cohort study	39	Patients admitted to hospital because of a whiplash injury.	4-15 days after the accident; 2 year follow-up period	All patients (13/39) with medullary impingement had persistent or increased symptoms and (3/27) with no or slight changes on MRI had persistent symptoms.	
Voyvodic	1997	Case series	29	Patients with whiplash injury following relatively minor road traffic crashes. (Adelaide Metropolitan area)	Shortly and at 6 months after the crash.		There were no statistically significant associations between the outcome of injury and spondylosis or loss of lordosis.
Radanov	1991	Prospective cohort study	78	Patients with common whiplash.	6 months	Older age was associated with persistent symptoms	Sex, education, injury mechanism, accident fault, and time from injury to initial study examination.
Harder	1998	Retrospective cohort study	1551	Individuals who sustained a whiplash injury resulting from a motor vehicle crash (Quebec, Canada).	Followed for 6 years	Female gender, older age, having dependents, not having full-time employment	Area of residence, marital status, net income
Swartzman	1996	Retrospective study (using questionnaires)	62 (group I: 41; group II: 21)	Group I: whiplash patients in the process of litigation; Group II: whiplash patients who had completed litigation. The two groups did not differ in demographic characteristics, employment status, or psychological distress.		Litigants reported more pain than post-litigants.	Litigation status did not predict employment status.

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<b>First author</b>	<b>Year of publication</b>	<b>Type of study</b>	<b>Number of patients</b>	<b>Description of patient population</b>	<b>Time of assessment</b>	<b>Factors that are associated with the development of a chronic whiplash</b>	<b>Factors that are not associated with the development of a chronic whiplash</b>
Brault	1998	Experiment: exposure to controlled low-speed rear-end collisions (4 and 8 km/h)	42	Healthy volunteers.	Immediately and 24 hours after impact.		No significant difference in the presence and severity of WAD between men and women at 4 and 8 km/h or in the duration of WAD at 8 km/h. Also no significant difference in presence, severity and duration of WAD between 4 and 8 km/h.
Cassidy	2000	Population-based cohort study	7462	People who filed an insurance claim for a traffic injury. Group 1: tort system. Group 2: no fault system.	Last 6 months of the tort system, and the first and second six-month periods of the no-fault system	Incidence of claims was higher for women than for men in each system. As a consequence of switching from a tort to a no fault system, the median time from the date of injury to the closure of a claim decreased from 433 days to 194 (men) and 203 (women) days. The intensity of neck pain, the level of physical functioning, and the presence or absence of depressive symptoms were strongly associated with the time to closure in both systems.	

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
Cote	2001	Retrospective cohort study	5398	People who filed an insurance claim for a traffic injury. Group I: tort system. Group 2: no fault system.	Participants were surveyed 5 times over 1 year.	Lower pain, better function, and absence of depressive symptoms are strongly associated with faster time-to-closure and recovery after whiplash, independent of the insurance system.	
<b>Psychological factors</b>							
Radanov	1991	Prospective cohort study	78	Patients who sustained common whiplash in car accidents.	6 months		Life history, personality traits, and 'current' psychosocial stress
Radanov	1992	Retrospective cohort study	54	Patients who sustained common whiplash in car accidents.		Results indicate that headache due to cervical pathology is likely to be responsible for impaired attentional functioning of "common whiplash" patients.	
Van der Donk	1991		5,440	Men and women between 20 and 65 years.		Disc degeneration was associated with neck pain in men but not in women.	
Radanov	1996	Prospective cohort study	42 (Group I: 21; Group II: 21)	Group I: patients who suffered trauma-related symptoms over 2 years. Group II: patients who showed complete recovery from trauma-related symptoms	2-year follow-up	Significant difference on Well-Being and Nervousness Scale	No significant difference on Depression Scale

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
				during the 2-year follow-up.			
Borchgrevink	1997	Prospective cohort study	Group I: 99 at intake; 88 at follow-up.	Group I: patients with neck sprain injury. Group II: a group of health personnel. Group III: patients with localized musculoskeletal pain. Group IV: patients with major depression.	6 months after the injury		The study does not support the view that premorbid personality traits can predict outcome for neck sprain patients.
Karlsborg	1997	Prospective cohort study	34	Acute whiplash injury without direct head trauma within the preceding 14 days.	Clinical exams: < 14 days, after 1 month, and 7 months post-injury. Other tests: one month post-injury and repeated after 6 months, if abnormalities were found.	Stress at the same time predicted more symptoms at follow-up.	The correlation between MRI and the clinical findings was poor. Cognitive dysfunction as a symptom of brain injury was not found. All MEP examinations were normal.
Cote	2000	Population-based cross-sectional survey mailed to a stratified random	2184, of which 55% participated	Saskatchewan adults aged 20-69 years.	6 months.	A positive association was found between a history of neck injury in MVC and headaches that moderately/severely impact on one's health.	No association was found between neck injury and depressive symptomatology.

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First author	Year of publication	Type of study	Number of patients	Description of patient population	Time of assessment	Factors that are associated with the development of a chronic whiplash	Factors that are not associated with the development of a chronic whiplash
		sample of adults.					
<b>Crash related factors</b>							
Sturzenegger	1994	Cohort study.	137	Patients who have been involved in a motor vehicle collision and who were referred by their primary care physician.	Examination within 7.2 days after trauma.	Rotated or inclined head position at the moment of impact, unpreparedness of the victim, and rear-end collision.	Passenger position in car, use of seatbelt, and the presence of a head restraint.
Harder	1998	Retrospective cohort study	1551	Individuals who sustained a whiplash injury resulting from a motor vehicle crash (Quebec, Canada).	Followed for 6 years	Occupancy in a bus or truck, being a passenger in the vehicle, colliding with a moving object, and being in a head-on perpendicular collision.	Severity of the crash, seatbelt use, and the authorized speed limit in the crash location.

**APPENDIX B: SUMMARY TABLE ON TREATMENT FOR WHIPLASH**

<b>Treatment</b>	<b>First author</b>	<b>Year of publication</b>	<b>Type of study</b>	<b>Number of patients (m/f)</b>	<b>Description of patient population</b>	<b>Outcome measures</b>	<b>Time of assessment</b>	<b>Effects/conclusions</b>	<b>Side-effects</b>
Soft cervical collar vs. no collar	Gennis	1996	Controlled clinical trial	250; 196 in follow-up		Pain and complete recovery	6 weeks	No significant difference.	
Cervical collars vs. activation (first 14 days after the accident)	Borch-grevink	1998	Single-blinded, randomized treatment study	201 (81/120)	Patients with neck sprain from Emergency Clinic	Subjective symptoms (pain localization, pain during daily activities, neck stiffness, memory, and concentration) and visual analog scale measurements (neck pain and headache)	6 months	A significant better outcome for the act-as-usual groups on all outcome measures.	
Cervical collars (Group 1) vs. physiotherapy (Group 2)	Giebel	1997	Randomized clinical trial study	Group 1: 47 (19/28); Group 2: 50 (26/24); Controls : 50 healthy	Patients (16 -60 y) with neck, head or shoulder pain resulting from MVC registered within 3	State of health and pain	2 weeks; 12 weeks	Physiotherapy has clear advantages over treatment with collars	

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Treatment	First author	Year of publication	Type of study	Number of patients (m/f)	Description of patient population	Outcome measures	Time of assessment	Effects/conclusions	Side-effects
				persons (25/25)	days of MVC.				
Chiropractic treatment	Woodward	1996	Retrospective study	28 (8/20)	Sustained whiplash injuries after MVC.	Severity of patients' symptoms (Gargan and Bannister classification)	Before and after treatment	All patients improved following chiropractic treatment	
Immobilization (group 1) vs. mobilization and advice for exercises at home (group 2) vs. advice for exercises + postural alignment (group 3)	McKinney	1994	Randomized clinical trial (three groups)	247	Whiplash patients	Cervical movements, and patients' perception of their neck pain severity	1 month, 2 months, 2 years	Significant improvement in the two groups with actively mobilized patients	
Regular treatment group (group 1) and additional exercise treatment group (group 2).	Soderlund	2000	Randomized study	59	Symptomatic (neck pain, stiffness, etc.) patients with acute whip-lash injury.	Pain Disability Index, Self-Efficacy Scale, Coping Strategies Questionnaire, neck range of motion, head posture, kinesthetic sensibility, visual analogue scale.	6 months	Home exercise as prescribed in the regular treatment group seems to be sufficient treatment for acute WAD patients when used on a daily basis.	



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Treatment	First author	Year of publication	Type of study	Number of patients (m/f)	Description of patient population	Outcome measures	Time of assessment	Effects/conclusions	Side-effects
Four groups: Active versus standard treatment and early (within 4 days) versus delayed (after 2 weeks) treatment	Rosenfeld	2000	Prospective randomized trial	97 (88 at follow-up)	Patients with a whiplash injury caused by an MVC.	Measures of range of motion and pain.	6 months	In WAD patients treatment with frequently repeated active submaximal movements combined with mechanical diagnosis and therapy is more effective in reducing pain than a standard program of initial rest, recommended use of a soft collar, and gradual self-mobilization.	
Standard exercises (group 1) vs. phasic exercises (group 2). Both groups got chiropractic therapy.	Fitz-Ritson	1995	Randomized, controlled, double blind study	30	Chronic cervical injuries		8 weeks	Group 1 improved by 7,4% and group 2 improved by 48,3%	
Home cervical traction	Swezey	1999	Retrospective study	58	Outpatients - Grade 1 to 3			Of grade 1 patients 100% improved; of grade 2 patients 77% improved; of grade 3 patients 90% improved.	
PEMT collar (group 1) vs.	Foley-Nolan	1992		40 (20 with	Grade 1 and 2 patients	Pain, range of ROM, use of analgesics.	4 weeks;	At 4 weeks - group 1: larger decline of mean pain rating,	

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Treatment	First author	Year of publication	Type of study	Number of patients (m/f)	Description of patient population	Outcome measures	Time of assessment	Effects/conclusions	Side-effects
sham PEMT collar (group 2). All patients: NSAIDS and advice. At 4 weeks patients could add physiotherapy.				PEMT; 20 controls )	that were referred from an emergency department within 72h. of MVC		12 weeks	improvement of ROM score (not in group 2), and decline of use of analgesics (not in group 2). By the end of 12 weeks, there was no significant difference in pain rating or ROM.	
Discectomy and anterior cervical fusion	Algers	1993	Retrospective study	20 (7/13)	Patients with chronic symptoms after whiplash	Headache, neck pain, paresthesia, radicular pain	4 years	Based on Robinson's criteria 2 patients had good results, 9 had fair results and 9 had poor results	
Greater occipital nerve release	Mag-nusson	1996		13	Patients with deep aching pain in occipital area due to a whiplash trauma			72,2% of the operations were reported as good or excellent, although complete pain relief was not attained in any patient	

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Percutaneous radiofrequency neurotomy	Lord	1995	Audit	Group 1: 10 third occipital neurotomy. Group 2: 10 lower cervical branch neurotomy.	Patients with pain from the cervical zygapophys eal joints	Pain relief, resumption of activities of daily living		In group 1, four patients obtained long-lasting pain relief. In group 2, 7 obtained complete pain relief for clinically useful periods and were able to resume activities of daily living	Brief periods of postoperative pain; ataxia was side-effect of third occipital neurotomy
Percutaneous radiofrequency neurotomy vs. control treatment using an identical procedure, but the radiofrequency current was not turned on	Lord	1996	Randomized double-blind trial	24 (9/15)	Patients with pain in one or more cervical zygapophys eal joints after MVC	Time elapsed before pain returned to 50% of preoperative level	27 weeks	Median time was 263 days in the active-treatment group and 8 days in the control group; at 27 weeks, 7 patients in the active-treatment group and 1 in the control group were free of pain	5 patients in active-treatment group had numbness in territory of treated nerves, none considered it troubling.
Percutaneous radiofrequency neurotomy vs. control treat-	Wallis	1997	Randomized, double-blinded, placebo-	17 (9/8)	Patients with pain in a single cervical	Pain and psychological status	Pre-operatively; 3 months	All patients who obtained complete pain relief exhibited resolution of their pre-operative psychological	

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ment using an identical procedure, but the radiofrequency current was not turned on			controlled trial		zygapophys eal joint		postoper atively	distress.	
Percutaneous radiofrequency neurotomy vs. control treatment using an identical procedure, but the radiofrequency current was not turned on	McDo-nald	1999	Randomized controlled trial	28 (14/14)	Patients having cervical zygapophys eal joint pain	Time elapsed before pain returned to 50% of preoperative level	Continu ous; not fixed.	Median duration of relief after a first procedure was 219 days when failures are included, but 422 days when only successful cases are considered.	
Intraarticular steroid injection: 0.5% bupivacaine (group 1) vs. 2% lidocaine (group 2).	Barns-ley	1994	Randomized control trial	41 (16/25 - 1with-drew); Group 1: 2 (8/13); Group 2: 20 (8/12)	People (age over 18) referred to spine center, neck pain attributed to MVC, lasting >3 months.	Verbal assessment of pain.	1, 4, 8, 16, and 20 weeks after injection	The duration of pain relief did not differ significantly between steroid and local anesthetic groups.	

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Subcutaneous sterile water injection vs. saline infiltration	Byrn	1993	Randomized trial	20	Patients with neck and shoulder pain 4 to 6 years after whiplash injury.	Pain and cervical ROM		The sterile water group had a greater improvement in reported pain and cervical ROM.	
Injections with botulinum toxin-A	Freund	1999	Prospective study	8 (2/6)	Chronic (grade 2), good health, undergone extensive conservative therapy in past with minimal success.	Composite range of neck motion (ROM), subjective pain, and tenderness to palpation.	2, 4, 6, and 8 weeks	All patients responded to the therapy with some improvement.	
Zygapophyseal joint injections	Slipman	2001	Retrospective study	18	Chronic head-ache patients (after whiplash event) who failed to improve after 3 months of physical therapy,	Headache frequency, medication usage, symptom response to medication, and employment status.	Average of 19 months after the final injection .	Initial findings suggest that therapeutic intra-articular zygapophyseal joint injections are effective in the treatment of headaches emanating from the C2-3 joint after a whiplash event.	

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					activity restriction, use of oral analgesics.				
High-dose methylprednisolone	Petter-son	1998	Prospective, randomized, double-blind study	40 (22/18)	Patients with complete diagnosis, start of treatment < 8 hours after injury.	Disabling symptoms, number of sick days before and after the injury, sick-leave profile after injury	6 months	Significant difference between the actively treated patients and the placebo group on all outcome measures.	
Tenoxicam	Szpal-ski	1998	Randomized, double-blind, parallel groups, using a comparative study design.	51 (16/35), 25 (2 withdrew)	Patients presenting whiplash injuries < 72 hours of MVC + QTF I or II	VAS pain assessment and function assessment	Day 1 and 15	Both groups had a favorable evolution during the study on both outcome measures. The beneficial effect of tenoxicam, however, is significantly larger than the effect in the placebo group.	No side-effects leading to exclusion from the study.
Multimodal treatment (group 1) vs. control treatment using physical agents (group 2)	Pro-vin-ciali	1996	Randomized controlled trial	60 (25/35)	Patients recruited < 2 months after neck injury	Pain level, range of movement, self-rating scale of treatment efficacy and return-to-work delay	Before + at end of treatment + 30 and 180 days after randomi	Benefit obtained in group 1 was greater and longer lasting than that experienced using B.	

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							zation		
4-week multimodal treatment program	Vendrig	2000	Descriptive study	26	Grade 1 or 2 whiplash lesions of the neck, persisting symptoms of > 6 months' duration	Pain intensity, number of painful sites, self-reported disability, symptoms of somatic and psychological distress, cognitive symptoms, return to work, medication and medical and paramedical treatment	6 months	Complete return to work (65%); complete or partial return to work (92%); no use of analgesics in the past 6 months (58%); no medical or paramedical treatment in the past 6 months (81%).	
Prescribed function vs. physiotherapy (incl. McKenzie and Maitland mobilization)	McKinney	1989	Two randomized control-led trials		Grade 1 or 2 whiplash patients presenting < 72 hours of MVC	Cervical ROM and long-term symptoms		Advice to mobilize, perform exercises and to minimize activity and dependence was at least as effective as physiotherapy.	
Acupuncture vs. drugs and physiotherapy only	Fattori	1996		15	Whiplash patients with balance disorders	Posturographic evaluations with open eyes, closed eyes and closed eyes with retroflexed head	Before and after sessions	Significant difference regarding the reduction of CER Length of the statokinesigram just before each session of acupuncture and reduction of the frequency oscillations of the patients, whereas in the	

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								control group there was a progressive increase in these values.	
Magnetic neck-lace vs. sham magnetic necklace	Hong	1982	Randomized trial	52 (25 active; and 27 sham necklace)	Neck and shoulder pain of >1 year .	Reported pain	At baseline and after 3 weeks.	No differences between the two groups.	