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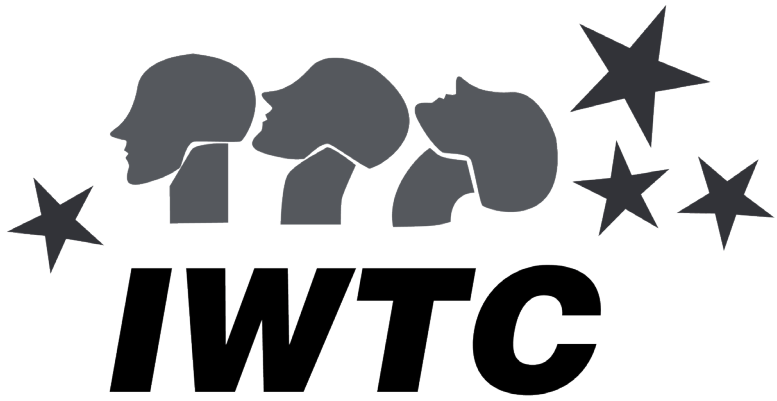

Fifth International Whiplash Trauma Congress 2011

Lund, Sweden, 2011

WELCOME TO LUND, SWEDEN

We are pleased to welcome you to the 5th International Whiplash Trauma Congress (IWTC). This Congress will be a gathering place for presentation of the most advanced and enlightened concepts regarding whiplash trauma and injuries. The focus of the 5th IWTC will be the multidisciplinary approach to understanding whiplash trauma; clinical, epidemiologic, engineering and biomechanical, as well as legal and forensic perspectives. There will be pre- and post congress courses and meetings, key-note lectures, poster-sessions and workshops.

This congress has been made possible by an unique initiative from the Region Skåne to create a center of excellence for pain after (whiplash-) trauma, at Skåne University Hospital, Department of Rehabilitation Medicine, in Lund.

We are very pleased to have support and sponsorship for the 5th IWTC from the University of Lund, University of Aarhus, Oregon Health & Science University School of Medicine, Event in Skåne, the City of Lund, the Swedish Pain Society, the Scandinavian Pain Society and the consumer organization Personskadeförbundet, RTP.

Marcelo Rivano-Fischer
Congress Chairman

and

Michael Freeman
Hans Westergren
Eva-Maj Malmström
Christopher Centeno
Scientific co-chairs

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IWTC 2011

Fifth International Whiplash Trauma Congress

Lund, Sweden August 24–28, 2011

Multidisciplinary approaches to pain after Whiplash trauma.

What works, what doesn't and how to tell the difference.

Topics:

Epidemiology
– What is *it* and who gets *it*?

Injury mechanisms and prevention
– How do you get *it* and how do you avoid *it*?

Pathology
– What is *it* that gets hurt?

Diagnosis
– How do you find *it*?

Treatment
– What can be done about *it*?

Forensic and medicolegal issues
– Can you prove *it*?

www.kongresslund.se/IWTC

Organizing committee:

Chairman:
Marcelo Rivano, Lund

Scientific co-chairmen:
Michael Freeman
Hans Westergren
Eva-Maj Malmström
Christopher Centeno

IWTC
Fifth International Whiplash Trauma Congress 2011
Lund, Sweden, 2011

Lund University Faculty of Medicine · Region Skåne · event in skåne – part of business region skåne · Oregon Health & Science University · Aarhus University · Personskadeförbundet RTP · Swedish Pain Society

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Reviewers

MARCELO RIVANO-FISCHER, PHD, PSYCHOLOGY

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HANS WESTERGREN, PHD, MD, REHABILITATION MEDICINE, ALGOLOGY, NEUROSURGERY

EVA-MAJ MALMSTRÖM, PHD, RPT

PRE CONGRESS PROGRAM

WEDNESDAY AUGUST 24

0900–1700	**Motor Learning and Training for Neck Pain Disorders** *Deborah Falla, RPT, PhD, Associate Professor* Clinical Workshop

PROGRAM

	THURSDAY AUGUST 25	***FRIDAY AUGUST 26***	***SATURDAY AUGUST 27***
Theme	**Who gets it?**	**What is it?**	**What can you do about it?**
0900–1030	***Moderator: Michael Freeman*** Welcome/Opening *Marcelo Rivano-Fischer* ***I 01*** Why a Multidisciplinary Approach and the Need for a Congress *Hans Westergren* ***I 02*** "Whiplash-Associated Disorders": the Persisting Lexicon of a Failed Venture *Michael Freeman* ***I 03*** Why and how? The Embryology and Development of the Human Neck *Hannes Petersen* ***I 04***	***Moderator: Pia Maly Sundgren*** MRS, fMRI and the Patient. Can Central Pain be Visualized? *Pia Maly Sundgren and Eva Kosek* ***I 11a, I 11b*** Visualization of Peripheral Painful Processes Using Positron Emission Tomography and [11C]-D-Deprenyl *Torsten Gordh* ***I 12*** Clinical Application of Digital Motion X-ray *Evan Katz* ***I 13*** Restoration of Normal CSF Flow… *Scott Rosa* ***I 14***	***Moderator: Christopher Centeno*** Cervical Radiofrequency or Biologics for Facet Injury? *Christopher Centeno* ***I 22*** The Role of Motor Learning in the Management of Pain *Deborah Falla* ***I 23*** Assessment and Exercise of Sensorimotor Function in Neck Pain Disorders *Ulrik Röijezon* ***I 24*** Pharmacological Alternatives: Mechanisms and Goals *Hans Westergren* ***I 25***
1030–1100	**Morning break**	**Morning break**	**Morning break**
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1230–1330	**Lunch and Poster session**	**Lunch and Poster session**	**Lunch and Poster session**

1330–1500	***Moderator: Jan Lidbeck*** Understanding Post-traumatic Fibromyalgia within the Broader Context of Post-stress Chronic Pain Conditions *Daniel Clauw* ***I 08*** Sympathetic Modulation of Motor Function. Is it Good or Bad? *Silvestro Roatta* ***I 09*** Presenting "The Risk Assessment Score" as a New Grading System in Whiplash Injuries *Helge Kasch* ***I10***	***Moderator: Marcelo Rivano-Fischer*** Neck Trauma and Mild Traumatic Brain Injury – What is the Difference? *Britt-Marie Stålnacke* ***I 19*** Is there a Place for a Neurodynamic Approach for Patients with Whiplash Associated Disorders? *Michel Coppieters* ***I 20*** The Jaw System – A Functional Part of the Head and Neck *Birgitta Häggman-Henrikson* ***I 21***	***Moderator: Michael Freeman*** **Workshop 3** Immobilization or Mobilization in Acute Neck Trauma Patients *Mark Rosenfeld* ***O 12*** Case Report: Sympathetic Nervous Activity with Severe Muscular Dysfunction and Pain that was Moderated by Zygapophyseal Blocks and Ganglion Impar Blocks *Johan Hambraeus* ***O 13*** Pain Neurophysiology Education Improves Cognitions, Pain Thresholds and Movement Performance in People with Chronic Whiplash: A Pilot Study *Jessica Van Oosterwijck* ***O14*** "Trigger Point" Surgery for Soft Tissue Pain in Chronic Whiplash Syndrome *Åke Nyström* ***O 15***
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1700–1730	Summary of the Day *Deborah Falla and Beth Winkelstein*	Summary of the Day *Mikael Karlberg and Jan Lidbeck*	
1930		Congress dinner	

INVITED PRESENTATIONS

I 01

WELCOME TO THE 5TH INTERNATIONAL WHIPLASH TRAUMA CONGRESS

Marcelo Rivano-Fischer
Skåne University Hospital, Department of Rehabilitation Medicine and Lund University, Department of Health Sciences, Lund, Sweden

Pain is a complex and unpleasant but vital human experience, a companion of mankind from its very beginning. Its expression is well documented since people started to record visually and otherwise how they experience their lives and the world they inhabit. Efforts to understand and treat pain have lead to many successes. We are gaining insights into its development and consequences. Nevertheless we are still struggling with many puzzles about pain such as how it develops into a persisting condition and how the many biological, psychological and social factors involved, interact and influence each other. We understand that the experience of pain in itself is complex, involving many aspects, from the level of the cell to the level of emotions, cognitions and socio-cultural actions. Therefore we welcome this multidisciplinary congress as one step in the right direction to a better understanding of the complexity involved in pain arising after neck trauma and how it may develop into causing devastating disability. Bringing researchers together from the many areas involved in the study of pain after neck trauma is a necessary but not a sufficient step. From this and similar gatherings, contact areas are established, common understanding may develop, and hypotheses and results have a possibility to converge into common grounds. It is essential to bring specialists in different fields together and promote their interaction. The county of Scania understood this necessity and gave our Department the financial means and the responsibility to actively work both to seek and bring together knowledge about pain and to disseminate this knowledge to benefit our clinicians and citizens. As Chair of this congress and in behalf of our colleagues that made this meeting a reality it is a pleasure for me to welcome you to the 5th International Whiplash Trauma Congress in Lund, Sweden.

I 02

WHY A MULTIDISCIPLINARY APPROACH AND THE NEED FOR A CONGRESS

Hans Westergren
Skåne University Hospital, Department of Rehabilitation Medicine and Lund University, Department of Health-Sciences, Lund, Sweden

Pain and dysfunction following trauma to the upper spine in general and especially after whiplash trauma is one of the most challenging medical and juridical problems today. Why is it so?

What is it and who gets it?
Most people who are affected by whiplash trauma are innocent victims that just happened to be at the wrong place at the wrong time. You can even say that the exposure to whiplash trauma is to a great extent randomized. Very simplified, the whiplash trauma occurs when the head and the body of a person are moving in opposite directions creating translatory movements in the horizontal plane, as well as stretching and compression of the structures in the head, neck and upper thorax. This is a fairly common trauma mechanism affecting 1–3/1,000 individuals/year in western societies. Risk factors have been identified for both getting injuries from the whiplash trauma and for developing persistent/chronic pain.

What is it that gets hurt?
The general "targets" for the whiplash trauma mechanism are the muscles (deep/stabilizing or global), the joints and ligaments (facet joints, discs or ligaments) and the nerve structures (spinal cord, spinal nerve roots or brachial plexus) of the neck.

How do you find it?
A main problem is that post traumatic changes in these structures seldom show up on radiological or neurophysiological investigations. Furthermore, pain in these structures may also evoke reactive changes in the perception of pain (sensitization) as well as psychological distress and social complications, creating a complex and very stressful situation, for the patient. Analysing the patient can therefore be difficult. In order to find the pain generating structures, assessments of a full rehab team as well as treatment of sensitization, psychological distress and help with the social situation are sometimes required.

What can be done about it?
After the analysis of the patient you have to clarify which targets/problems you intend to treat as well as inform the patient of the expected effects of selected treatment. The general aim, using the Rehabilitation method, is both to decrease pain, restore function and promote an acceptance for the new situation.

Can you prove it?
A further challenge to the "whiplash problem" is that different insurances and insurance systems are involved. This means that the patients' symptoms have to be defined not only within a treatment perspective but also to explain why they have arisen. This can be difficult partly due to lack of consensus in the medical professions, a main reason why we need a congress.

I 03

"WHIPLASH-ASSOCIATED DISORDERS": THE PERSISTING LEXICON OF A FAILED VENTURE

Michael Freeman[1]; Christopher Centeno[2]
[1]Oregon Health & Science University School of Medicine, Public Health & Preventive Medicine, Portland, and [2]Centeno Schultz Clinic, Denver, USA

Vetti et al. recently published two papers regarding MRI imaging of the upper cervical ligaments of 111 whiplash trauma-injured patients who were followed for a year after injury (1) and a subsequent controlled cross-sectional study of the same group of injured patients compared with 157 uninjured subjects (2). The authors reported no significant differences in the proportion of grade 2–3 high signal intensity changes in the alar and transverse ligaments in their study groups, and concluded that trauma does not contribute

to such changes when they are present, nor are they causally linked to chronic pain after whiplash trauma. The conclusions of these authors were not supported by their methods, and in fact were almost certainly a product of error in study design. The study design error resulted, in part, from the system of categorizing injury following a traffic collision known as "Whiplash-Associated Disorders" ("WAD") categorization scheme set forth nearly 16 years ago by the insurer-financed Quebec Task Force and published in a special pull-out supplement of the journal Spine (3). This "Task Force" consisted of a number of researchers and clinicians from various fields, virtually none of who had previously published on the topic of injury following whiplash trauma. The apparent primary goal of the authors was to ignore any research indicating that a substantial minority of such injuries result in persisting pain and disability as was indicated by their literature review, and instead to conclude that the injuries are "not harmful" and are "self limited" as a matter of consensus based on speculation (4). Hundreds of studies published prior to and subsequent to the "WAD" paper have conclusively demonstrated that injury following whiplash trauma is neither benign or self-limited in a subpopulation of acutely injured patients, yet 16 years later the pernicious effects of this fallacious endeavour still persist, as is evident in the methods described by Vetti et al. in the aforementioned studies. The injury inclusion criteria used by these authors were the invalid and largely meaningless "WAD" system of grading neck injury following whiplash trauma (5). The only patients included in the study were graded "WAD" I and II, and the relative proportions of each were not reported in either study. The criteria for "WAD I" are any degree of neck pain, but no objective findings of injury. The "WAD II" criteria include findings of musculoskeletal injury but no neurologic symptoms or findings likely indicative of more significant injury. As injury to the upper cervical ligaments injury is a possible explanation of persisting symptoms in only the most chronically and significantly injured patients following whiplash trauma, evaluating a least-injured cohort of patients with little or nothing in the way of objective indication of injury guarantees the lowest probability that there will be substantial pathologic differences between the "injury" groups and controls. This fact is born out by the reporting by the authors in their cohort study that only 23 of 111 initially injured subjects went on to have chronic symptoms of injury at 12 months, and yet in the study no pathologic basis for the chronic pain was described as having been investigated. An additional error made by these authors that further hampered the ability of their studies to detect real upper cervical injuries was the inclusion of overall "grey" appearing (i.e. not indicative of traumatic injury) ligaments in their grade 2 category. The non-injury diluted grade 2 category was combined with the grade 3 category for the analysis, with no indication of how many subjects in each group were grade 3 versus grade 2. As a grade 3 ligament finding (high signal intensity in 2/3 or more of the ligament) is a stronger indication of real injury than is a grade 2 ligament (1/3 to 2/3) (6), and real grade 2 ligament injuries were diluted by the inclusion of the uniformly grey definition that is unlikely to be indicative of injury, it appears that the authors designed their study to fail to find real signs of injury. With no information regarding how many patients had only grade 3 findings, and how many of these patients were also chronically injured, the results of neither study can be said to have any meaning with regard to upper cervical ligament injury following trauma. It is certainly possible that, although there were similar proportions of grade 2–3 ligaments found in the injured and uninjured populations in the case-control study, the subset of chronic patients among the cases had a significantly greater proportion of grade 3 findings in comparison with the least injured and uninjured populations. Indeed, this is precisely what we found in a study published by Myran et al., in which the authors described the upper cervical MR imaging of 3 groups of subjects; whiplash trauma patients, chronic neck pain patients, and asymptomatic subjects (7). As was the case with the case-control study by Vetti et al., Myran et al. found no significant difference in the frequency of grade 2–3 alar ligaments between the groups, drawing similar conclusions as Vetti and colleagues. Unlike Vetti et al. however, Myran et al. provided a breakdown of ligament grades among the whiplash injured, chronic pain, and asymptomatic subjects. Our post hoc analysis of their data demonstrated a prevalence of grade 3 findings that was approximately three times greater in the whiplash-injured cohort than among the two uninjured comparison groups (6). It is reasonable to question whether a similar important finding is hiding among the data presented by Vetti et al. The errors in the research by Vetti and colleagues were in part due to the failure of the "WAD" categories to add any predictive or other clinical meaning to their study design. The system does nothing but promote the concept that such injuries are unobjectifiable because they are not real. It is time that the whiplash trauma research community abandons this lexicon of a failed venture.

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I 04

WHY AND HOW? THE EMBRYOLOGY AND DEVELOPMENT OF THE HUMAN NECK

Hannes Petersen

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Human posture is dependent on the coordination of numerous biomechanical constrains where central integration of vestibular, visual and somatosensory information is used to stabilize equilibrium and orientation. Equilibrium refers to stabilizing the center of mass in erectile human within the base of support, while orientation refers to the relative

or absolute positions of different body parts such as trunk and head. Proprioception of the neck may be particularly important to integrate vestibular and visual information with somatosensory information from the rest of the body to estimate the position and motion of different body parts in space. Perturbation of neck proprioception, by means of neck muscle vibration, is known to affect postural control during upright quiet standing. The musculature introducing the proprioception of the neck is arranged in a series of three layers, of which only the two profound are true intrinsic neck muscles, characterized by position and innervation by branches of the dorsal rami of the spinal nerves. The term "whiplash" is regarded as a forceful shift of the head in any cardinal plane, causing severe tissue injury to the cervical structures such as muscles, ligaments, fascia, intervertebral disc, nerves, facet joints, articular cartilage, and joint capsules. The embryology and development of these neck structures are interesting from evolutionary point of view and give insight in the anatomy and function of the neck. Key elements of cervical spine evolution and development will be addressed, as the consistency of seven cervical vertebrae in mammals and its connection to the occiput of the head. The evolution and development of the supportive and dynamic neck muscles will be evaluated in the scope of erect posture and head stabilization in healthy state.

I 05 a

WHIPLASH-ASSOCIATED DISORDERS – INJURY MECHANISMS, DIAGNOSTICS AND PREVENTION

Olle Bunketorp

Department of Orthopaedics, Sahlgrenska Academy, Göteborg, Sweden

The mechanisms contributing to the development of whiplash-associated disorders (WAD) are poorly understood, and several paradoxes obstruct the understanding and treatment of this plague of road traffic. To solve this dilemma, fundamental biomechanical facts should be recognized, as should the neurophysiologic and bio-psycho-social processes associated with it. The injury risk of a specific segment of the loaded cervical spine is determined by the deformation of the segment's various tissues and their points of failure. The forces causing the deformation are determined by the inertia of the head and the asynchronous rapid movements of the head and the upper trunk during impact. Stiff structures increasing the car acceleration cause paradoxical effects, and the impact severity is often misjudged from the visible car damage. Rear-end impacts cause greater relative head-trunk movements and a greater injury risk than other types of impact, because of the elasticity of the car seat, even at low speed impacts. Asymmetric loads also increase the injury risk. Even if we do not know the injury mechanisms exactly, the protection principle should be to minimize these relative movements. The protection systems in new cars, based on this principle, have reduced the risk of WAD substantially, showing the structural correlate of WAD. Understanding the injury mechanisms is important also for diagnostics, because injuries are seldom visualized. The medical history is fundamental and should be early documented by protocols as well as the clinical findings. Imaging procedures including MRI and CT are sometimes indicated, although the diagnostic criteria are not optimal, especially for the craniocervical junction. This most complex part of the spine, with the greatest amount of proprioceptors, and located near the brain stem has gained focus during the last years. The interpretation of aberrant MRI ligament signals, vertebral misalignments, and spinal cord impingements must be improved, as should the technique for detecting disturbances of the nervous system, including those caused by biochemical processes of injured vertebral disks. FE models have a great potential for understanding of what can be injured and the injury mechanisms. However, these models must be adapted for asymmetric loading, representing the most hazardous conditions. Early follow-up procedures are necessary for individuals at risk, and existing algorithms for supplementary measures should be applied when necessary. Post-traumatic stress is a risk factor and should be managed early. Three months is a critical limit, as the pain processing properties of the nervous system may change paradoxically quite early in some individuals. Diagnostics also imply a description of the injury cause. To distinguish between post-traumatic symptoms and other symptoms is important when causation is judged – but difficult, especially after some time. Muscular pain and dysfunction are common in chronic WAD as in the general population. An earlier history of neck pain, depression, anxiety, and stressful life events are related to worse prognosis after whiplash trauma. However, that does not proof causality. Consensus about causation criteria has to be reached soon in order to avoid judicial processes preventing rehabilitation. A multidisciplinary approach is utterly needed to solve the WAD enigma. The last years have offered some clues, but much remains obscure. Hopefully, our understanding will grow during the coming decade. Until then, we must treat the victims with respect and try to learn from each of them.

I 05 b

REDUCING THE RISK OF NECK INJURY SEQUELAE; INJURY MECHANISMS AND PREVENTION

Mats Y. Svensson[1]; Gunter P. Siegmund[2]; Beth A. Winkelstein[3]; Anita Vasavada[4]; Lotta Jakobsson[5]; Paul C. Ivancic[6]

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Whiplash injury is the most common most poorly understood traffic injury. Literature supports an organic basis for whiplash injuries. Several anatomical sites have been proposed, including, facet joints, spinal ligaments, intervertebral discs, vertebral arteries, dorsal root ganglia, and neck muscles. Each of these tissues is strained during a whiplash exposure. A review of Siegmund et al. (1) found: Two mechanisms of facet joint injury have been proposed: pinching of the synovial fold and strain of the capsule. The cervical vertebrae have been shown to rotate about an elevated instantaneous center during whiplash exposure. This may compress the posterior facet surfaces, pinching the synovial fold. Excessive facet capsule strain has been demonstrated. Injuries to the neck ligaments and intervertebral discs have been documented.

Ligament injuries may cause acute neck pain and lead to chronic spinal instability. Injured mechanoreceptors may corrupt normal sensory signals and could lead to abnormal muscle response patterns, decreased neck mobility and proprioception. Chronic symptoms of headache, blurred vision, tinnitus, dizziness, and vertigo have been proposed to be associated with altered blood flow rates due to spasm and/or narrowing of vertebral arteries in whiplash patients. Intimal tears of the vertebral artery are most common at the atlanto-axial joint. This has been hypothezised to be caused by coupled extension and axial rotation of the upper cervical spine. The dorsal root ganglia contain the cell bodies of most peripheral sensory nerves at each spinal level. Injury could explain many whiplash symptoms. Increased electrical activity in the spinal cord and widespread reductions in electrical and pressure thresholds after whiplash suggest altered central pain processing. Increased sensitivity to pain and larger areas of referred pain are also reported. During whiplash motions, pressure transients have been registered in the spinal canal. These are hypothesized to be the cause of spinal ganglion nerve cell injury. Direct deformation of the nerve roots is another possibility as the neural foramina decrease their diameter during extreme neck motions. Muscle pain is a common whiplash symptom, although evidence of direct injury to muscle remains inconclusive. Direct muscle injury may not be responsible for chronic pain, but may play an indirect role in modulating pain caused by injuries to other structures. The direct mechanism of muscle injury occurs from imposed lengthening during active contraction. Both anterior and posterior muscles experience active lengthening. Neck muscles interact with other anatomical sites: 1) they attach to the facet capsule; 2) they indirectly load other neck structures; 3) altered neuromuscular control may contribute to chronic pain. For each of these tissues, continued research is needed to help improve the diagnosis and treatment. In spite the lack of a confirmed injury mechanism some car manufacturers have developed anti-whiplash systems based on engineering judgment. Volvo Cars biomechanical guidelines state: 1) Reduce occupant acceleration; 2) Minimize relative spine movements; 3) Minimize occupant rebound. This was the basis for the Volvo WHIPS-system focusing on: 1) head restraint geometry; 2) backrest properties and; 3) WHIPS controlled yielding recliner system. The WHIPS system has proven to substantially reduce the risk of long term whiplash symptoms.

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I 06

CENTRAL HYPEREXCITABILITY. CLINICAL IMPLICATIONS

Jan Lidbeck

Skåne University Hospital, Department of Rehabilitation Medicine, Lund, Sweden

The past decades have presented increasing evidence that chronic pain in musculoskeletal disorders, including whiplash syndrome, is related to abnormal excitability of nociceptive pathways in the central nervous system. Such central hyperexcitability (dysfunctional central pain modulation) has been described as a conceptual breakthrough in the understanding and treatment of chronic pain. Chronic pain patients with central hyperexcitability present with a spectrum of other symptoms such as allodyni/hyperalgesia, diffuse or widespread pain, muscular weakness and non-dermatomal sensory deficits. Abnormal aftersensations and sustained pain even after non-noxious stimuli is another charateristic feature. Often, such diffuse and seemingly non-organic symptoms are misdiagnosed as unexplained pain, somatization, neuropathy, or radiculopathy. In pain research facilities, central hyperexcitability can be diagnosed by the use of objective assessment methods. In the clinic, however, central hyperexcitability can be recognized from the clinical characteristics that differentiate it from nociceptive, neuropathic or psychogenic pain. Some important implications: 1) Clinicians need to recognize and diagnose central hyperexcitability from its clinical features and differentiate it from other causes of chronic pain. 2) In uncertain cases, and prior to the recommendation of potentially harmful or invasive procedures, consultation with a pain specialist may prove beneficial. 3) Improved professional understanding and recognition of central hyperexcitability as a legitimate cause of chronic pain will promote a more positive doctor–patient relationship. Patients provided a valid diagnostic explanation of their complaints suffer less from catastrophizing and improve their coping strategies.

I 07

TALKING ABOUT PAIN. IS IT JUST IN MY IMAGINATION?

Marcelo Rivano-Fischer

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Health care providers establish diagnoses and treatments out of standardized physiopathological analyses. The process is selective and symptom specific. It relies on providers being specialized or having access to specialists. Patients seek health care due to their experience of symptoms and illness. Their health experience includes disease-related process as well as other negative factors. Nevertheless, patients expect to meet experts working with disease-specific hypotheses. Diagnoses provide caregivers with objective information about the health status of patients. Diagnoses' importance correlates positively with the probability of their linking to specific treatments. Diagnoses provide patients with a key to enter the health care system. Diagnoses' importance increases if they link to sound explanations about what patients do experience. Health care providers and patients communicate. Doctors view communication as a process of instrumental information exchange about objective facts and treatment strategies. Patients view the same process as ways of a) establishing trustworthy relations with caregivers and b) adaptation to the demands they understand are exerted on them by providers as representatives of the health care system. Some of the rules governing communication processes in health care are: 1) A physiopathological explanation for the information conveyed by patients is available. 2) Patients are expected to behave properly, behavior deviation used as a diagnostic tool. 3) Patients should report symptoms related to sickness rather than to illness. Caregivers are in control of the communication process by means of organizing meetings; deciding about their intensity, frequency, location, structure, content and purpose. Relations between patients and caregivers are constructed as fitting or not fitting into the biomedical model of health. Matters such as gender,

social status, cultural belonging, age and economic status are usually not considered to impinge into the doctor–patient relationship. Pain is an unpleasant sensorial, emotional and cognitive experience either associated with actual or possible tissue damage OR described in such terms. Pain is both experienced and communicated. Patients and providers ignore this complexity, focusing on sensorial information and on whether the pain is somatic or not, the main rule being that somatic pain is the one understood by caregivers. Providers view reported pain as a symptom of something else going on in the body. Patients experiencing pain do not make distinctions between chronic and acute pain. Their strategies are usually acute pain strategies, mainly focused on flight and fight as well as on cues from the environment. As acute pain develops into chronic pain, other strategies are called for, but these will be out of reach unless a sound non-acute pain explanation is offered, one in which pain no longer is a sign for something else going wrong, but a problem in itself. Pain and symptoms arising after distinct physical traumata are expected to develop following a strictly somatic-sensorial perspective on pain, and failure to do so leads to questioning the whole pain experience as a real one. Poorly understood medical conditions including many and varied symptom reports, will make the communication process between providers and patients a very difficult one. The fruitless distinction between somatic and non-somatic pain, more general, the Cartesian distinction between body and mind becomes central to the process, leading to conflict escalation and deterioration.

I 08

UNDERSTANDING POST-TRAUMATIC FIBROMYALGIA WITHIN THE BROADER CONTEXT OF POST-STRESS CHRONIC PAIN CONDITIONS

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Every year, billions of individuals are exposed to traumatic and stressful life events. Sexual and physical abuse, major infections, motor traffic accidents, surgical procedures, and deployment to war are amongst such traumatic events that occur commonly. Most individuals that experience such events are left with no chronic sequelae. But evidence suggests that 5–15% of individuals exposed to a variety of severe, subacute stressors go on to develop a chronic multisymptom illness characterized by chronic pain, fatigue, sleep disturbances, and mood difficulties (1–4). Some of the risk of developing such sequelae is likely to be genetic, with strong evidence at present implicating genes involved in monoamine metabolism playing some role (5–7). A variety of early life traumatic events, ranging from motor vehicle collisions or prolonged hospitalizations, to maternal illness or financial hardship, all increase the risk of having chronic pain later in life by 50–100% (8). The cognitive setting in which the stressful event occurs (e.g., catastrophizing, expectating a poor outcome, absence of perceived control or social support) might also be an important role in determining which individuals will transition from an acute stressor to having a chronic multisymptom illness. Changes in activity levels (i.e. individuals with high pre-morbid levels of physical activity who cease to be active following the stressful event because of pain or medical advice) or sleep patterns may also play a significant role in determining progression or spontaneous resolution. Individuals at highest risk for this transition from acute to chronic pain can theoretically be identified so that interventions could be designed for primary and secondary prevention. In addition to the above factors, female sex, anxiety or depression, a personal history of chronic pain in any body region(s), and a family history of chronic pain are all likely markers for individuals that are biologically at higher risk for developing chronic symptoms. Implementing such a system is simpler said than done. The ideal scenario (which may be difficult to achieve) is likely to be that restore the individual to pre-morbid functional status as rapidly as possible. Adequate acute pain relief is probably important, but it is possible that certain classes of analgesics (opioids) could do more harm than good in this setting. Similarly, although the overall goal is to reinforce a cognitive context that there is no expectation on the part of the individual that they will develop chronic symptoms, this is the opposite of what occurs in many clinical care settings. A popular US saying is "don't just stand there, do something" – in many cases the best medical advice we can give at present is "don't just do something, stand there".

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I 09

SYMPATHETIC MODULATION OF MOTOR FUNCTION. IS IT GOOD OR BAD?

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Activation of the sympathetic nervous system (SNS) accompanies motor activity providing the necessary vegetative support mainly in terms of potentiation of the cardiovascular system but also through a number of actions specifically exerted at muscle level. However, SNS activation also occurs under different types of stressful conditions, in the absence of a major motor activity. Is SNS activation still appropriate in these conditions or is it interfering with muscle and motor functions, with implications in the pathogenesis of musculoskeletal disorders as suggested by epidemiological data? Activation of the SNS is now known to be quite sophisticated, being differentiated to the different organs and tissues, also depending on the type of stressor/stimulus. It is mediated by the action of noradrenaline, released along with other peptides by sympathetic fibers, and by the hormonal action of adrenaline released by the adrenal medulla, both acting with different affinity on the many adrenergic receptors (alpha-1,alpha-2, beta and subtypes). Sympathetically-

released catecholamines affect muscle and motor function at different levels and these actions may be implicated in the pathophysiological mechanisms behind musculoskeletal disorders, including whiplash-associated disorders.

1) Control of muscle blood flow. SNS generally exerts a vasoconstrictor action. Reduced blood perfusion reduces muscle force and increases fatigue. It may be speculated that "low" muscle activity may be insufficient to antagonize the sympathetic vasoconstriction and that an imbalance between blood demand and actual perfusion may occur under "stress", possibly leading to hypoperfusion, reduced washout of metabolites, fatigue and pain.

2) Modulation of the contractile mechanism. Catecholamines modulate the contractile mechanism of skeletal muscle fibers in a complex way. The most relevant effect appears to be a weakening of type-I (low threshold) motor units, possibly associated with tremor. This effect would then call for compensatory changes of the motor strategy, e.g., increase in motor drive and co-activation of antagonist muscles to stabilize the movement, in both cases increasing the energetic cost of the motor task.

3) Modulation of afferent activity from muscle spindles. Several studies on experimental animal models have shown that activation of sympathetic pathways modulates their afferent activity as well as motor reflexes with a prevalent inhibitory effect. On this basis it could be speculated that the sympathetic action that reduces the feedback control of muscle length impairs movement precision thereby again calling for different and suboptimal compensatory motor strategies. However, this mechanism has not yet been unequivocally evidenced in humans. In summary, these actions by SNS have a functional meaning in the context of an emergency reaction subserving and improving the performance of an intense and fast motor activity ("fight or flight"). However when stress and sympathetic activation occur in a different context, e.g., during sedentary work, these actions may be not only useless but potentially harmful. The hypothesized increased muscle work and reduced perfusion may increase the local concentration of metabolites and further excite the SNS via group III-IV afferents thus giving rise to a vicious circle possibly contributing to the development and maintenance of chronic muscle pain.

I 10

PRESENTING "THE RISK ASSESSMENT SCORE" AS A NEW GRADING SYSTEM IN WHIPLASH INJURIES

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Background: The de facto standard in more recent whiplash literature rules out whiplash-associated disorders (WAD) grades 0+IV from being whiplash (WL) injuries. The WAD grading system is of limited value in predicting recovery or treatment response. Clinicians need tools to segregate WL patients into different risk strata based on early findings. *Methods:* We concluded two clinical prospective studies to examine the expediency of applying stratified risk assessment diagnostics to WL patients. Firstly, we performed a 1-year observational study of 141 acute WL patients and 40 gender/age-matched acute non-sport ankle sprain patients with similar disability and global pain within 1st week after injury; however, only in the WL group non-recovery was encountered. Neurological examination was carried out at first visit + semi-structured interviews performed at 1 week, 1, 3, 6, and 12 months + The McGill Pain Questionnaire (MPQ), SCL-90R, The Copenhagen Neck Functional Disability Scale. The importance of sensitization of the nociceptive system as a mechanism for non-recovery was studied in a prospective setting, e.g. development of the functioning of the DNIC system, cold pressor pain, the development of remote and regional deep pain by means of a pressure algometry and methodical palpation technique, and furthermore we measured active neck mobility (CROM test) and measured maximal voluntary contraction and duration for neck flexion and neck extension. Secondly we performed a multi-centre randomized controlled trials of 740 acute WL-patients segregated into high- and low-risk strata based on risk factors (intense neck pain/headache, multiple non-painful symptoms and a reduced active neck mobility) derived from the former observational study. *Results:* High-risk patients had a ten-fold risk of 1 year work disability. Elaborating further on the risk score, we found it was robust in order to predict 1-year work disability. Receiver operating characteristics estimations for study 1 (riskscore/1-year work disability; ROC area = 0.89) and sensitivity-specificity plots are presented with significant predictive values. From a clinical perspective we found it meaningful when examining data in both studies to segregate the risk score into 7 risk strata. Risk strata were nicely supported by descriptors of MPQ ($p < 0.004$ KW), and SCL-90R derived parameters (WHIP, COGN, SLEEP) and The Copenhagen Neck Disability Index dovetailed with the risk strata ($p < 0.002$ KW). From clinical measurements tenderness of muscles (Somedic Algometer) $p < 0.002$ and methodical palpation ($p < 1.78 \times 10^{-6}$), time to peak pain during the cold pressor test ($p < 0.01$) were also distributed in concordance with the risk strata. Neck strength examination of maximal voluntary contraction (MVC, Follo, Norway) gender-spit, for neck flexion $p < 0.001$; extension ($p < 0.004$); duration (60% of MVC) of flexion ($p < 0.001$) and extension ($p < 0.001$). *Conclusion:* Stratification is easily done by the GP, PT, and in the units. We suggest that *"The Risk Assessment Score"* is applied in future stratification of WL patients in the clinic, and in research. Measures in study 1 (and 2) took place within 1 week after injury, however all risk factors are timely robust and distributed in separate trajectories over time for at least a 1-year observation period in our material. This model is bio-psycho-socially robust concerning the psychological, the social and work-related as well as the painful and non-painful features of WL injuries.

I 11 a

FUNCTIONAL MAGNETIC RESONANCE IMAGING (FMRI) – CAN PAIN BE VISUALIZED?

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Pain can be rated but not objectively visualized. However, with fMRI an indirect assessment of cerebral activation can be obtained and related to ratings of ongoing pain or to painful stimulation. Acute pain stimulation in healthy subjects activates the "pain matrix", including thalamus, primary and secondary somatosensory cortex, anterior cingulated cortex (ACC), insula, cerebellum and certain motor areas and this activation is correlated to the perceived pain intensity (1). The "pain matrix" is activated also during evoked pain stimulation in chronic pain patients. However, less intense pressure stimulation was needed to evoke the same subjective pain intensity as well as similar "pain matrix" activations in fibromyalgia (FM) (2, 3) and chronic low back pain (CLBP) patients (4) compared to healthy controls. Furthermore, compared to controls, the same absolute pressure stimuli caused higher pain ratings and more extensive cerebral activation in the patient groups (2, 4) signifying increased transmission and/or processing of nociceptive input. Recently, a failure to activate the first link in the descending pain regulatory system rostral ACC has been shown in FM patients during pain stimulation (3), supporting a dysfunction of endogenous pain inhibition in FM. Furthermore, the increased sensitivity to pressure pain and the corresponding increase in pressure pain related cerebral processing was found independently of depression or anxiety in FM patients, suggesting that segregated mechanisms are involved in the neural processing of experimental pain and negative affect (5). Although "pain matrix" is activated during evoked pain it is not always the case during perception of chronic pain. In fact, no typical "pain matrix" activation was found in CLBP patients during periods of stable ongoing high intensity back pain. Instead areas related to cognitive and emotional evaluation of pain as well as pain modulation were activated (i.e., medial prefrontal cortex (mPFC) and rACC). "Pain matrix" activation was seen only during periods of increasing back pain intensity (6). Furthermore, clinically relevant pain, i.e., joint pain in patients with osteoarthritis or rheumatoid arthritis (RA), caused greater activations of mPFC or rACC compared to cutaneous heat pain (7, 8) and activation of mPFC was increased in RA patients with high ratings of depression (8). These results suggest that the perception of chronic pain is more related to the suffering dimensions rather than the sensory-discriminative aspects of pain perception. To our knowledge, no imaging studies have been performed during evoked pain in patients with whiplash-associated disorder (WAD), however, altered cerebral resting state activity suggesting increased self-relational evaluation was reported using positron emission tomography (PET) in WAD patients (9). Therefore, psychological mechanisms affecting baseline activity in endogenous pain modulatory systems as well as activation of these systems during increasing pain intensity must be considered in chronic pain patients.

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I 11 b

MR SPECTROSCOPY AND DIFFUSION WEIGHTED IMAGING - CAN CENTRAL PAIN BE VISUALIZED?

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The underlying mechanisms of many pain conditions are not known and many conditions have no effective treatment. The advent of modern dynamic neuroimaging has provided tools to reveal central pain processing and to help explain many intractable pain syndromes. These tools have increased the understanding of altered central nervous system processing in different chronic pain conditions and the underlying mechanisms mediating treatment response to pharmacological or other therapeutic interventions like acupuncture or nerve stimulation. These techniques include conventional magnetic resonance imaging (MRI) and new advanced MR techniques such as fMRI, MR spectroscopy (MRS), and diffusion weighted imaging. The most basic pain neuroimaging methods evaluate the location and pattern of neural activity evoked by a painful or non-painful stimulus. We know from previous pain studies that such painful stimulation commonly activates thalamus, and primary and secondary somatosensory cortex, cerebellum, anterior insular and cingulate cortices, basal ganglia and both frontal regions and posterior parietal cortex the so called "pain matrix". MRS is a non-invasive MRI technique that quantifies the biochemical metabolites in brain or other tissue. Most commonly used is 1H (proton) MRS due to high natural abundance of protons, high absolute sensitivity to magnetic manipulation, better spatial resolution, and relative simplicity of technique. Recently, MRS studies have been performed in patients with different conditions like chronic back pain, complex regional pain syndrome type 1, chronic neuropathic pain, and fibromyalgia (FM). In many studies have MRS like in previous fMRI studies demonstrated involvement of the anterior cingulate cortex in the affective processing of pain. Commonly seen is a reduction in N-acetyl aspartate (NAA), that have been seen in several brain regions suggesting that NAA might be a marker for

chronic pain – indicating neuronal degeneration. In addition, recent MRS studies have demonstrated an increase in glutamate in the insular region in patients with fibromyalgia. Diffusion weighted imaging (DWI) and diffusion tensor imaging (DTI) measures the mobility of water molecules. A recent study of patients with spinal cord injury (SCI) demonstrated significant changes in mean diffusivity (MD) in pain-related regions as well as in regions of the classic reward circuitry. For example increased MD was found in right posterior parietal cortex, right DLPFC, left anterior insula, medial orbitofrontal cortex, and the premotor cortex while decreased MD was present in ventral midbrain, left amygdale and right ventroposterior thalamus in SCI patients with pain compared to SCI without pain. Both MRS and DTI have been used to study changes in patients with fibromyalgia. Other advanced MR imaging techniques like arterial spine labelling, functional connectivity and resting state as well as voxel based morphometry might add new insights to the pain conditions. In the presentation different imaging methods with special emphasis on fMRI, MRS and diffusion imaging (DWI) and their role in imaging central pain will be reviewed and discussed.

I 12

VISUALIZATION OF PERIPHERAL PAINFUL PROCESSES USING POSITRON EMISSION TOMOGRAPHY AND [11C]-D-DEPRENYL

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There are few diagnostic tools for chronic musculoskeletal pain as structural imaging methods seldom reveal pathological alterations. This is especially true for whiplash-associated disorder (WAD), for which physical signs of persistent injuries to the neck have yet to be established. Here, we sought to visualize inflammatory processes in the neck region by means positron emission tomography (PET) using the tracer C11D-deprenyl, a potential marker for inflammation. Twenty-two patients with enduring pain after a rear impact car accident (WAD grade II) and 14 healthy controls were investigated. Patients displayed significantly elevated tracer uptake in the neck, particularly in regions around the spinous process of the second cervical vertebra. This suggests that whiplash patients have signs of local persistent peripheral tissue inflammation, which may potentially serve as a diagnostic biomarker. In another study we used patients with acute ankle sprain as a model of acute and chronic pain. The aim was to explore if pain and inflammation as well as change of pain with the healing process following traumatic injury can be visualized and quantified using PET with [11C]-D-deprenyl. Eight otherwise healthy patients with unilateral ankle sprain were imaged acutely and followed up twice, first one month and then up to over one year after injury. Acutely [11C]-D-deprenyl uptake was significantly increased by a factor 10.7 (range 2.9–37.3) in the injured as compared to the intact ankle. During healing [11C]-D-deprenyl uptake was reduced, but not normalized until after 11 months. Patients with persistent pain showed prolonged [11C]-D-deprenyl uptake in the injury sites. Preliminary data from translational animal studies will be presented as well. In conclusion, our investigations demonstrate that painful processes in the periphery can be objectively visualized and quantified with PET imaging, and that C11D-deprenyl is a promising tracer for these purposes.

I 13

CLINICAL APPLICATION OF DIGITAL MOTION X-RAY

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Digital motion X-ray (DMX), video fluoroscopic examination of the joints of the spine and extremities, is a medical diagnostic procedure that is nearly as old as plain X-ray. The technique has a number of applications in the clinical setting including identifying and evaluating cervical biomechanics to assess cervical instability. For more than 30 years DMX has been described in the literature as useful means of assessing cervical spine pathomechanics, including a loss of ligamentous integrity and stability, following whiplash trauma (1–4) DMX is considered a valuable diagnostic tool for determining upper cervical instability by detection of alar, accessory, and transverse ligament injuries. By assessing movement of C1 on C2, as well as movement of the occiput the clinician can evaluate the integrity of the upper cervical ligaments (5–8). Early detection of upper cervical ligament injuries may help direct treatment in order to minimize chronicity in patients as well as identify the source of symptoms associated with these injuries such as headaches, vertigo, pain and nausea because of the proximity of C1 the brain stem (9). DMX allows the clinician to assess the spine through its full range of motion. Identifying and quantifying vertebral angulations and translation, not just at the end ranges of flexion, extension, lateral flexion, and rotation (like standard radiographs), but throughout the full range of motion to assess both translational and angular movement pathologies that may give greater insight into the patients' injuries.

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I 14

RESTORATION OF NORMAL CEREBROSPINAL FLUID FLOW IN 2 CASES OF CONFIRMED CEREBELLAR TONSILLAR ECTOPIA WITH LONG-TERM HEADACHES, FOLLOWING USE OF THE ATLAS ORTHOGONAL INSTRUMENTED MANIPULATION TECHNIQUE

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Introduction: We report on two patients who presented with severe, long-standing headaches and other complications following whiplash trauma secondary to a motor vehicle crash (MVC). *Materials and Methods:* Both patients were examined in an upright MRI utilizing cerebral spinal fluid (CSF) flow cine software, which allowed for evaluation of CSF flow. It was noted that in each patient there was a static misalignment of the 1st cervical vertebra (Atlas), as well as substantially reduced CSF flow at the cranio-cervical junction associated with cerebellar tonsillar ectopia. Both patients received a manipulation directed at the C1 misalignment utilizing the atlas orthogonal procedure (instrumented manipulation). *Results:* Within an hour of the atlas orthogonal correction both patients were rescanned for CSF flow. In both cases restoration of normal flow was observed. Additionally, the headache pain level was nearly eliminated immediately post treatment in both patients. Subsequent follow-up has demonstrated persisting improvement in headache severity, with similar nearly instantaneous results with the same procedure of instrumented manipulation when the headaches symptoms have returned. *Conclusions:* Prior research has demonstrated a correlation between CSF flow obstruction and intracranial pressure headaches. This is a potentially significant clinical finding (CSF obstruction) that can lead to long-term and often unexplained complaints of unresolved headaches, neck pain, paresthesias, numbness, and a variety of other symptoms that are often associated with cerebellar tonsillar ectopia. A larger study with a control group is currently underway to evaluate the reproducibility of these findings.

I 15

POSTMORTEM STUDIES AFTER NECK TRAUMA – WHAT HAVE WE LEARNED?

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Whiplash injuries, following acceleration/deceleration traumas (whiplash trauma), are sustained by approximately 300 per 100.000 inhabitants annually in the western world. Approximately 10% of the injured will suffer impairment/disability, and 30–40% will continue to suffer from chronic symptoms. Neck pain is the most common painful symptom following a whiplash injury, and consequently this has been a focus of research studies, with postmortem studies focusing on identifying somatic injuries. Currently, there is no pathognomonic whiplash injury, although numerous studies have identified a range of somatic tissue injuries. The diagnosis whiplash injury is not defined by the severity of the trauma, e.g. velocity changes, and the diagnosis is given to people subjected to both high-energy as well as low-energy trauma. Hence, investigation of deceased exposed to high- as well as low-energy trauma is relevant to the understanding of whiplash trauma and injury. *Postmortem studies:* Numerous postmortem studies have been performed after neck trauma, some including controlled settings and histological methods. Postmortem studies of the cervical spine of people killed in road traffic crashes have revealed a range of lesions, including the obvious extensive crush/compression and distraction injuries of the cervical spine causing significant tissue damage that is clearly visible to the naked eye. In addition, more subtle non-fatal injuries have also been identified, including among others injuries to the facet joints (articular cartilage, synovial fold, subchondral bone, haemarthrosis), intervertebral discs, nerve roots and musculature. Previous reviews have demonstrated the important role of microscopic postmortem investigations in elucidating traumatic pathology that is not otherwise apparent. Hence, imaging occult injuries have been identified in the cervical spine, confirming that conventional X-rays, CT, and MRI do not currently have the ability to identify all types of somatic injuries following road traffic trauma. The injuries identified in postmortem studies generally have nociceptive potential, which can explain the acute onset of pain. As a consequence of acute injury, persistent secondary conditions may arise, e.g. synovitis, premature degeneration of the articular cartilage, altered biomechanics of the cervical spine and sensibilization (hypersensitivity) of both peripheral tissues and the central nervous system. These are common findings in whiplash injured patients. *What have we learned?* Based on postmortem studies it is reasonable to assume that there is an under-diagnosis (missed diagnosis) of somatic injuries in the cervical spine following whiplash trauma, and that these injuries have clinical relevance in subgroups of patients for the course of symptom development. Whiplash trauma does indeed have the possibility of producing injuries that can be objectively demonstrated. The distribution and incidence rate of such injuries is currently unknown. Numerous discrete types of somatic lesions have been identified using microscopy that could not have been identified by other means, including advanced diagnostic procedures. This supports the fact that imaging occult cervical spine injuries need to be considered a possible source of symptoms in patients with neck pain after whiplash injury. With future advancements in diagnostic imaging procedures, the unique knowledge derived from postmortem studies is likely to contribute increasingly to our understanding and management of whiplash injury.

I 16

NEUROMUSCULAR ADAPTATIONS FOLLOWING NECK TRAUMA

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The pain and injury of whiplash induces altered neuromuscular function of the cervical spine. Individuals who have suffered a whiplash injury are known to have impaired neck strength, which is apparent around all axes. Furthermore, patients with whiplash show an impaired ability to maintain a steady neck contraction around a target force value.

Changes in motor output are accompanied by alterations in muscle strategies. Evidence suggests that neck pain may alter the task-related modulation of neck muscle activity so that motor control of the cervical spine is solved by alternative, presumably less efficient, combinations of muscle synergistic activities. For example, the activity of the deep semispinalis cervicis muscle is reduced and less defined in patients with neck pain during multidirectional isometric tasks and is associated with increased activation of the superficial extensor, the splenius capitis. Furthermore, increased activity of the sternocleidomastoid muscle has been seen consistently in patients with neck trauma during various tasks ranging from isometric contractions to functional upper limb activities. An additional feature which may be present in patients following neck trauma is a reduced ability to relax the neck muscles following contractions. For example, persistent motor unit activity has been observed for the sternocleidomastoid muscle of patients with neck pain despite the instruction to fully relax their muscles. The strategy of increased activation of the more superficial neck muscles, despite being inefficient, may reflect an attempt to voluntarily increase the stability of the head for the fear of performing potentially painful movements or the need to compensate for decreased activity of the deeper muscles. Furthermore, the increased neural drive to the superficial neck muscles which has been observed in patients may reflect an attempt to enhance kinesthetic sense by muscular contraction since increased muscle activity can enhance the acuity of movement detection. A reorganization of neck muscle activity may have short term benefits as it allows motor output to be maintained during sub-maximal tasks. However, in the long term pain-induced altered neural control may dispose some muscles to overload and, as a consequence, injury and other muscles to reduced activity with consequent atrophy of specific fiber types. Ultrasound and magnetic resonance imaging studies have confirmed alterations in the physical characteristics (fatty infiltrate and changes in cross-sectional area) in the cervical extensor and flexor muscles in patients with chronic trauma-induced neck pain and biopsies from various neck muscles in neck pain patients have revealed alterations in muscle fiber composition. Thus, long term alterations in motor control may partially explain the morphological and histological changes documented in the cervical muscles in people with neck pain. Moreover, impaired neuromuscular control of the cervical spine may predispose spinal structures to mechanical strain and perpetuate chronic symptoms. Changes in muscle behavior appear early after neck trauma and do not automatically reverse over time in the absence of specific training interventions. This highlights the need for rehabilitation programs to incorporate training to address neuromuscular control as part of the overall management of a patient with trauma-induced neck pain.

I 17

THE FACET JOINT AS A PAIN GENERATOR IN NECK TRAUMA

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Injury to the cervical facet joint can occur during whiplash and has been shown to produce neck pain. The spinal facet joint anatomy dictates its biomechanical role in the spine's normal function and also in the altered spinal responses in injury and degeneration. The bilateral facet joints have a complicated anatomy, with similarities and differences among the different regions of the spine. A growing number of studies provide compelling evidence to support tensile loading of the facet joint and its capsule as a means of painful injury. The basic general anatomy of this joint provides specific indications of how its anatomical features provide its relevance to stability, injury and pain. In particular, the joint cartilage and enclosing capsular ligament both have key roles in the function of the normal and injured joint. In addition, the anatomical features of these joints have distinct roles in their biomechanics and also the kinematic and kinetic responses of the spine overall. Our lab combines biomechanical approaches in cadaver models with a rodent model of neck pain mediated by facet capsule distraction to investigate the relationship between joint loading, capsule responses, cellular mechanisms of nociception, and spinal injury producing facet-mediated pain. This presentation will integrate findings from several painful *in vivo* loading conditions in the rat model with biomechanical and imaging studies of isolated ligament specimens. Together, this collection of physiological and kinematic data will provide a multi-metric view of the local and central mechanisms which contribute to injury of the facet capsule, development and maintenance of pain following its loading and potential direction for therapeutic interventions. We emphasize the relationship between the local biomechanics of the capsular ligament and its joint's structural response, and use these data to synthesize a framework for understanding the complete picture of whiplash-mediated neck pain. Part of the work presented in this talk comes from studies funded by the National Science Foundation, National Institutes of Health, and the Catharine Sharpe Foundation.

I 18

UNSTEADINESS – A PAIN IN THE NECK?

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Dizziness and unsteadiness are commonly reported symptoms after head and neck trauma. In every day life the different sensory inputs provide proper perception for optimal motor control aiming counteract the effect of gravitation during motion and stance. Cervical proprioception is important for head on trunk orientation since it provides vital information about the position of head relative the trunk. Interaction between the vestibular system, vision and cervical proprioception is also a prerequisite for proper head on trunk orientation and a derangement in this interaction may be suspected to induce balance disturbances. The importance of cervical proprioception is further supported by a multifold of muscle spindles in the region and by the reported continual interaction with the vestibular and visual systems. When the inputs become incongruent, a sensory mismatch might appear, perceived as dizziness or unsteadiness. Sensory mismatch due to changes in cervical proprioception after trauma can be attributed different structural and physiological phenomena. Increased muscle tension has experimentally been shown to make interact with sensory information increasing cervical sensibility to motion (Malmström 2010). Pain in itself can deteriorate sensory information which has been shown experimentally

(Falla 2011). Longstanding pain impairs sensory information with impact on sensorimotor control (Trealeaven 2003). The integrity and importance of cervical proprioception can seldom be documented and proved, but rather hypothesised and tested ex juvantibus in individuals. In patients suffering from dizziness and neck pain, and with a clinical suspicion of these symptoms being related, treatment of the cervical complaints might reduce the dizziness (Karlberg 1996, Malmström 2007). Sometimes do dizzy neck trauma patients also benefit from specific vestibular rehabilitation with reduction in perceived handicap and regained postural control (Ekvall-Hansson 2006). Postural control may be affected both in early and late stages after neck trauma, and thus should be addressed in analyses and treatment (Cobo 2009). Gaze stability has been reported to be impaired by disturbed cervical proprioception either by injury (Montfort 2008, Treleaven 2011) or by mere temporary fixation of the head (Karlberg 1995). Impaired muscular function prevertebral (Falla 2011) with reduced head stability has also been suggested to effect gaze by means of either reduced head stability per se, but also indirect by reduced sensory information from the involved muscles (Woodhouse 2010) or by disturbed interaction between the cervicoocular (COR) and vestibuloccular (VOR) reflexes (Montfort 2008). Furthermore, trauma to the head may also induce a posttraumatic benign paroxysmal positional vertigo (BPPV), which should always be considered in dizziness after accidents (Dispenza 2010), in analogue to BPPV in mountain bikers (Vibert 2007). There are thus many possible ethiologies for dizziness with neck pain after neck trauma, aside for the obvious central nervous lesions. And while BPPV may be tested for, we still lack a useful and accepted test for cervical proprioceptive dysfunction or cervicogenic dizziness.

I 19

WHIPLASH AND MILD TRAUMATIC BRAIN INJURY – WHAT IS THE DIFFERENCE?

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Whiplash injuries and mild traumatic brain injuries (MTBI) are common conditions with high incidences (100–300 per 100.000 inhabitants per year) that most often affect young persons in working age. Traffic accidents are a common injury mechanism of both MTBI and whiplash and some patients also suffer from manifestations from both these injuries at the same time. Patients often have similar complaints after a MTBI and whiplash injury with pain, headache, nausea, dizziness, visual impairment, fatigue and impairment of cognitive abilities. Although most people recover from both injuries, a percentage experience prolonged symptoms that may affect both work and leisure activities. However, since there are different pathophysiological mechanisms in MTBI and whiplash, as the injuries affect the brain and the neck, respectively, the management of these injuries differs. In order to investigate patients, to establish diagnoses correctly and to give adequate information and follow-up, it is of great importance that clinicians are aware of the symptomatology of these injuries in the acute and late phases. This presentation will address differences and similarities between whiplash and MTBI and discuss rehabilitation aspects.

I 20

IS THERE A PLACE FOR A NEURODYNAMIC APPROACH FOR PATIENTS WITH WHIPLASH-ASSOCIATED DISORDERS?

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Whiplash is a remarkably complex and heterogeneous condition involving diverse physical and psychological manifestations. Multiple structures may be affected, including the facet joints, intervertebral discs, vertebral bodies, nerve tissues and neck muscles. Relatively few studies explore the involvement of nerve structures, such as the dorsal root, dorsal root ganglion and spinal nerve. Injury to these structures may however explain many of the typical whiplash symptoms (Siegmund et al. 2009). Postmortem and biomechanical studies also point at their involvement. Due to a lack of clinical trials, the optimal management of neuropathies in general, and neuropathic arm pain in whiplash-associated disorders (WAD) more specifically, remains unclear. A recent study revealed that treatment options as diverse as exercise and immobilisation were equally effective in reducing arm and neck pain in patients with a recent onset of cervical radiculopathy (Kuijper et al. 2009). While acknowledging the importance of activity modification, and avoidance of pain provocative interventions in patients with WAD with widespread sensory hypersensitivity, there is also a role for manual therapy, including neurodynamic mobilisations, and exercise. With neurodynamic techniques, either the nervous system itself or the structures that surround the nervous system are mobilised. Recent studies have confirmed that different types of neurodynamic techniques have significantly different biomechanical effects on the nervous system (Coppieters & Butler 2008). At least in the arm, cadaveric data suggest that neural structures can be mobilised without significant increases in nerve strain. Although techniques have also been suggested to mobilise the nerve structures of the cervical spine without significant increases in nerve strain, no studies have quantified nerve strain or excursion of the spinal nerves or more proximal parts of the nervous system during different neurodynamic techniques. Techniques aimed to mobilise the surrounding structures relative to the nervous system have been evaluated. We demonstrated in a group of patients with non-traumatic neuropathic cervicobrachial pain that a cervical lateral glide had an immediate analgesic effect compared to a control intervention (Coppieters et al. 2001). Sterling et al. (2010) evaluated the same mobilisation technique in patients with chronic WAD and demonstrated a greater increase in the threshold of the nociceptor flexion reflex following the lateral glide compared to a control condition. Other outcome measures revealed no differences between groups. It seems reasonable to assume that this intervention influences central mechanisms, but peripheral mechanisms might not be discarded. Mobilisation of the nerve or surrounding structures may reduce intra- and extraneural oedema. This may reduce the pressure in and around the nerve, which may improve intraneural blood circulation and axonal transport. Furthermore, inflammatory mediators might be dispersed resulting in less ectopic impulse generation (Coppieters & Butler 2008). Studies investigating these proposed mechanisms are scarce and not available for WAD. However, an immediate reduction in extraneural pressure following exercises has been demonstrated (Seradge et al. 1995). Furthermore, based on findings from a recent animal study, Song et al. (2006) sug-

gested that improved blood circulation to the dorsal root ganglion following spinal mobilisation may explain the observed decrease in pain and hyperalgesia induced by inflammation in the intervertebral foramen.

I 21

THE JAW SYSTEM – A FUNCTIONAL PART OF THE HEAD AND NECK

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Relationship between the jaw and neck: One basic function of the human jaw system is to enable eating, i.e. mouth opening, biting, chewing and swallowing. These activities are executed by paired jaw muscles, which are jointly activated and interact with other muscle groups, requiring complex neuromuscular control for the specific tasks. Studies in animals and humans show a close biomechanical and anatomical relationship between the jaw and neck regions, which suggests a functional linkage between the trigeminal and cranio-cervical motor systems. Head–neck movements are influenced and even initiated by input from oro-facial structures, indicating that movement of the head is an integral part of normal oral function. *Integrated jaw- and neck function:* A series of studies have shown that jaw function involves coordinated activation of both jaw and neck muscles, with simultaneous movements in the temporomandibular, atlanto-occipital and cervical spine joints. Normally head extension occurs in jaw opening and head flexion in jaw closing. In fact, the head starts to move simultaneously with, or even before, the lower jaw, which indicates recruitment of neck muscle motor-neurons in a feed-forward mode. A proportional involvement of the neck motor system, with larger head movements in maximal jaw opening than in chewing a small soft bolus, has also been demonstrated. Chewing boluses of larger size and harder texture require not only larger jaw movements, but also larger head movements and increased neck muscle activity. Consequently, as jaw function comprises integrated control of jaw and head–neck movements, jaw behaviours such as mouth opening, biting and chewing rely on linked motor control of the jaw and neck motor systems. Given that natural jaw function involves not only the temporomandibular joint, but also the atlanto-occipital and cervical spine joints, neck pain and dysfunction following whiplash injury could impair jaw function. This hypothesis is supported by findings of disturbed jaw function in healthy subjects after experimental restriction of head-neck mobility. *Impaired jaw function in whiplash-associated disorders:* An association between neck injury and deranged jaw function has been found in individuals with chronic whiplash-associated disorders (WAD). The findings include reduced amplitude and disturbed coordination of jaw and head–neck movements, and impaired endurance during chewing. Patients with chronic WAD also report that jaw activities and eating are associated with pain and discomfort. Consequently, eating difficulties and avoidance of tough food and big pieces of food has been reported. Taken together, these findings suggest a putative association between neck injury and impaired functional capacity of the jaw motor system in chronic WAD. *Pain in the jaw and neck regions:* Patients with neck pain commonly present pain also in the jaw-face region and vice versa. The incidence of pain in one of these regions will also increase if pain exists in the other. Although it has been reported that the incidence of jaw pain following acute whiplash injury is low, some studies report that more than 30% of chronic WAD patients report pain and dysfunction also in the jaw-face region. *Conclusion:* Current research indicates associations between neck injury and impaired jaw function, and between pain in the jaw and neck regions. Taken together, these findings suggest that assessment of patients with neck pain and dysfunction should also include examination of the jaw region, and that a multidisciplinary approach is beneficial.

I 22

CERVICAL RADIOFREQUENCY OR BIOLOGICS FOR FACET INJURY?

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The elucidation of cervical facet injury as an injury mechanism secondary to MVC has created a new avenue of treatment that did not exist merely 20 years ago. While radiofrequency ablation (RFA) appears effective in many patients, it suffers from the inevitable side effects of denervation such as hyperalgesia and muscle atrophy. As a result, a new concept has arisen that may supplant RFA – the use of biologic agents to repair the damaged cervical joint. The anatomy of which structures are injured about the facet joint will be reviewed as well as various biologic strategies for joint repair. Data from peripheral joint cases ($n = 250$) will be extrapolated to cervical facet injury and several cervical facet cases where culture expanded mesenchymal stem cells have been injected intra-articular will be discussed. Finally, future directions for research and therapy will be postulated.

I 23

THE ROLE OF MOTOR LEARNING IN THE MANAGEMENT OF NECK PAIN

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A progressive understanding of the alterations of neuromuscular control of the cervical spine in the presence of neck pain has directed rehabilitation programs to include more specific therapeutic exercise regimes as a component of a multimodal intervention. In particular novel motor-skill training is known to be associated with rapid changes in cortical excitability as well as cortical re-organization, thus this training approach is considered relevant for treating patients with pain. A contemporary clinical approach that has been shown to be effective in the management of musculoskeletal pain disorders involves training the activation of a delayed or inhibited muscle with repeated isolated voluntary contractions. For example, patients with neck pain may be treated by repeatedly activating their deep neck flexor or extensor muscles independently of the more superficial muscles, which constitutes a novel motor task. The rationale for using this approach is based on the principle of novel motor-skill training, which places emphasis on improved performance of a movement component rather than the simple execution of a sequence of movements. The ability to target a specific component of movement requires greater skill and increased levels of attention and precision than

contraction of all muscles (e.g., strength training). In support of this approach, a six-week program of isolated training of the deep cervical flexors in patients with neck pain resulted in improvements in the amplitude and speed of activation of the deep cervical flexor muscles and improved the patient's ability to maintain an upright posture of the cervical spine during prolonged sitting. Similar outcomes were not achieved when patients with neck pain participated in six weeks of high load strength and endurance training for the cervical muscles. Isolated training of the deep cervical flexors also demonstrates immediate (one session of training), short-term (post 6 weeks of training) as well as a long-term (12 month follow-up) reductions of perceived pain, pain on neck movement and palpable tenderness of symptomatic cervical joints. Current evidence suggests that a reduction in pain alone is not sufficient to reverse neuromuscular changes in patients with chronic neck pain conditions. For example, manipulative therapy which is known to be effective for relieving neck pain, fails to improve control of the deep cervical flexor muscles. Thus there is no spontaneous improvement of muscle function despite the relief of pain. Specific neck exercises, based on the principles of motor learning, should thus be included as a key component of a multimodal intervention for the management of neck pain.

I 24

ASSESSMENT AND EXERCISE OF SENSORIMOTOR FUNCTION IN NECK PAIN DISORDERS

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Recent research on sensorimotor function has contributed essentially to the understanding of possible pathophysiological mechanisms, associations between pain and altered motor control and to the development of assessment and rehabilitation methods of musculoskeletal pain disorders. The sensory and motor functions of the cervical spine are fundamental for the stability and movement control of the head, for the arm and hand function, as well as for the postural control. Thus, sensorimotor deficiencies in neck pain disorders may have important impact not only regarding symptoms but also on physical functioning in daily living and work life. Pathophysiological models explaining the associations between pain and altered sensorimotor function include, e.g., disturbed proprioceptive information due to altered sensitivity of muscle spindle afferents, and altered muscle activation patterns due to pain adaptations. According to these models, sensorimotor deficiencies may be of immense importance for the recurrence, persistence and spread of musculoskeletal pain disorders. Assessments of sensorimotor function in neck pain disorders have revealed deficiencies including, e.g., reduced range of motion and movement speed of cervical movements; reduced acuity in movements of the neck, shoulder and elbow; and reduced muscle strength, as well as altered activation synergies of the deep and superficial cervical muscles. Disturbances have also been identified for occulomotor function and postural control, especially in neck pain related to trauma and cervicogenic dizziness. For references see, e.g. (1). In line with the above, specific exercise regimes designed to improve sensorimotor function, such as neck coordination and proprioception exercises, have shown promising results in reducing pain and improving motor functions, e.g., (2). A common characteristic of these exercises is that they involve slow movements and closed skills tasks (i.e., the task is highly predictable). According to the literature on motor learning, exercises involving more open skills tasks can be useful for training sensorimotor function. Therefore, new methods have been developed which involve less predictable exercises and thereby increase the demand for on-line adjustments of the neuromuscular control system (3, 4). Taken together, these theoretical and empirical premises support the value of assessment and exercise of sensorimotor function in the rehabilitation of neck pain disorders. Further research is, however, warranted, e.g., regarding the neuromuscular mechanisms involved in various types of exercises; the predictive ability of the efficiency of interventions for a specific individual; and RCT-studies including long-term follow-up.

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I 25

PHARMACOLOGICAL ALTERNATIVES – MECHANISMS AND GOALS

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The literature on whiplash-trauma and pharmacological treatment is to date sparse and there are no specific algorithms available, as for e.g. neuropathic pain. Due to the time-course of post-traumatic pain the patients may need different pharmacological strategies at different time-points. - What works at one time-point may or may not work at another. Therefore, the analysis of the patients' pain generators, psychological and social situation, as well as the degree of pain sensitization is mandatory for the planning of the pharmacological treatment. In the post-traumatic course the patients initially has a nociceptive pain as a result of the tissue damage. There can also be a direct nerve injury and subsequent neuropathic pain directly after the trauma, but more commonly neuropathic pain begins later as a result of an unfavourable healing process and/or due to the patients' movement patterns. Some patients will suffer from post-traumatic stress disorders after the trauma, while others may develop sleep-disorders, depression and/or anxiety problems due to the pain but also due to the response and reactions they get from their surrounding and the subsequent social and psychological consequences. So, when considering pharmacological treatment a clinician must first define which mechanism is being addressed. In discussions with the patient one must be realistic about the benefits and side-effects of the proposed pharmacological treatment. In pain rehabilitation the pharmacological treatment is often used as a means to open up for new treatment alternatives. The list of drugs available are, in brief: NSAID, COX-2-inhibitors, Paracetamol, Tramadol, Kodein and Opoiods for the nociceptive pain. SSRI, SNRI, Tricyclic antidepressants and Anti epileptic drugs for anxiety, depression and neuropathic pain and hypnotics for the sleep

disorders. The numbers needed to treat (NNT) varies between 3–4 for most of the drugs, so one must be prepared to change strategies, follow the patient closely, consider and reconsider the pharmacological treatments and possible combinations.

I 26

CAN SURGICAL STABILIZATION CONTRIBUTE IN ANY WAY?

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Patients with chronic pain syndrome after whiplash trauma treated with craniocervical fusion – a prospective study using single-case methodology. The hypothesis for our study is that whiplash injury can cause ligament ruptures in the craniocervical junction (CCJ), that these injuries may be a cause of chronic pain, and that fusion of the CCJ may relive the pain. We target chronic pain patients who have sustained indirect distortion trauma to their cervical spine, where an injury to the CCJ may be suspected on clinical grounds. The patients are investigated with functional MRI where head is kept in various extreme positions during the examination with the help of a physiotherapist. In unclear situations also functional CT is performed. Three criteria are applied for determining if a ligament rupture is present: If a rupture is visible, if the internal structure of the ligament is altered, i.e. the signal intensity from the ligament is indicative of a rupture, or if the osseous structures can be shifted outside what is normally stabilised by the ligaments, i.e. a subluxation can be seen. If two out of the three criteria are met the patient is classified as having a ligament rupture. The main ligaments investigated are the alar ligaments, the capsules of the C0–C1 and C1–C2 joints, and the tectorial membrane. Patients with suspected ligament injuries are fused between C0 and C2. For follow-up they fill out several validated instruments measuring various aspects of their situation and a pain diary on several occasions preoperatively and during two year thereafter. Single-case-statistics are applied where each patient serves as their own control. The study is planned to consist of 25 patients. So far 16 have undergone fMRI and 6 have been operated. Apart from a pilot investigation of the two first patients with promising results, no data is available.

I 27

INNOVATIVE PSYCHOLOGICAL APPROACHES TO CHRONIC PAIN: IT IS NOT WHAT YOU THINK!

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Psychologically-based, pain management, treatment courses are regarded as the most efficacious and cost-effective treatments for disabling chronic pain conditions. There are more then ten published meta-analyses of these treatments that support this conclusion. At the same time the effect sizes for psychological treatments for chronic pain emerging from a Cochrane review published in 2009 are smaller and less consistent than expected. We know that not all patients obtain significant, general, long term benefits from these treatments. Most psychologically-based treatments for chronic pain are based on a broadly Cognitive Behavior Therapy (CBT) model. Accumulating research suggests weaknesses in the model underlying these treatments and in the quality of treatment delivery. This research increasingly calls into question the need to reduce unwanted symptoms in order to improve patient functioning and the need to challenge negative thought and beliefs. From this background there are calls for greater focus on theory, therapy process, and integrity. While the field wrestles with how to progress there are directions available. These include "next generation" therapies, contextually-focused variants of CBT, or what are sometimes called acceptance and mindfulness-based therapies. One example of these is Acceptance and Commitment Therapy (ACT). ACT is unique as it relies heavily on non-didactic, experiential, treatment methods, explicitly works in the interaction of direct and verbally-based influences on behavior, and focuses specifically on a process called psychological flexibility. ACT is now regarded as an empirically supported therapy for general chronic pain by the Society of Clinical Psychology of the American Psychological Association. This talk will briefly review the evidence for psychological treatments for chronic pain, present the treatment model of ACT, and present recent research findings from this approach.

I 28

REHABILITATION – AN INTERDISCIPLINARY ALTERNATIVE

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Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck. The impact can result in bony or soft tissue injuries (Whiplash injury), which in turn can lead to a variety of clinical manifestations (whiplash-associated disorders, WAD). WAD account for a large proportion of the overall impairment and disability from traffic injuries. Rarely can a definite injury be determined in the acute (or chronic) phase. As with other pain conditions, some patients will develop chronic conditions. Recovery rates of acute WAD after one year with respect to persistent pain is approximately 60% according to recent systematic reviews. Persistent/chronic pain is not merely acute pain that persists over time; changes occur at different levels of the pain transmission system. The plastic changes induced in the peripheral and central nervous system will probably be less reversible when the stimuli remain and may be related to the pathogenesis of chronic pain. Chronic WAD is often associated with problems concerning social functioning, daily anxieties, and satisfaction with different aspects of life. When planning treatment for a patient with chronic WAD it is necessary to assess how complex the situation is and based on this determine how intense and broad interventions are needed in order to improve the situation. A broad screening technique with respect to different categories (impairment, disability, and global level) as well as coping strategies is considered as important. Hence, a bio-psycho-social model is generally necessary when assessing the patient with chronic pain. Based on clinical picture, pharmacological challenges, degree of pain and other symptoms or coping strategies it is evident that chronic WAD not is a homogenous pain condition; different subgroups can be identified. Classification of patients with chronic WAD into homogenous subgroups is an important objective in order to tailor interventions and to control for subgroup differences when evaluating treatment or rehabilitation outcome. For the more complex situations

multimodal rehabilitation can be an alternative. Rehabilitation can be viewed as a process of enhancing an individual's ability to reach or regain an optimal desired quality of life and perception of health consistent with his or her impairments and disabilities. The definitions of multimodal rehabilitation emphasize that synchronised and well planned activities over time are necessary together with the need to see the patient as an active and central part of the process in order to alter the situation in a multifaceted way for instance with respect to body functions, activity and participation and health and quality of life. Thus rehabilitation in chronic pain patients can be viewed as a coordinated multi-modal process. Several recent systematic reviews mainly based on randomized controlled trials report moderate to strong evidence for the effectiveness of multimodal rehabilitation in patients with chronic pain. In recent systematic reviews from the Swedish Cochrane institute (SBU) based on randomized controlled trials of multimodal rehabilitation of chronic pain with at least 6 months follow-up it was not possible to identify studies of chronic WAD. At present it is unclear if there is a need for special multimodal rehabilitation program for patients with chronic WAD or if these patients can participate in general multi-modal rehabilitation programs with significant positive outcomes.

I 29

WORKLIFE EXPECTANCY AFTER WHIPLASH TRAUMA

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Introduction: The economic consequences of whiplash trauma can be significant. Victims of a whiplash injury can experience either a diminution of physical functioning or cognitive functioning. In each instance, the effect on earnings and worklife expectancy are significantly reduced. The purpose of this presentation is to familiarize participants with the effect of whiplash injury on lifetime earning loss. *Materials and Methods:* In 2001, the U.S. Department of Commerce began conducting a macro survey entitled American Community Survey (ACS). Authorized by the Congress of the United States, the survey was designed to eliminate the historical 5% sample conducted during the decennial census. Conducted each month, an annual sample size of 5 million persons in the United States is conducted. The data are specific to both men and women at various levels of educational attainment. In addition, such data are reported for those without any type of disability versus those with either a cognitive or physical disability. *Results and Conclusions:* The results of the survey for both men and women with or without disability at various levels of educational attainment will be presented to the participants. Particular attention will be focused on males and females without disability and with a physical or cognitive disability who possess a professional degree. The ACS defines a professional degree as existing for those persons with a professional doctorate which includes medical doctors, doctors in juris prudence, etc. The survey differentiates between persons delivering a professional service to individuals as opposed to persons with a PhD who are involved in work as a university or college professor or researcher. The ACS defines physical disability as existing when an individual has a condition that substantially limits one or more basic physical activities such as walking, climbing stairs, reaching, lifting, or carrying. A cognitive disability is defined as existing when an individual has a physical, mental, or emotional condition lasting six months or more resulting in limitations associated with learning, remembering, or concentrating. Traumatic whiplash injury can result in either a physical impairment, a cognitive impairment, or both. When traumatic whiplash injury is permanent and the result of a tort, a probable future lifetime loss of earning capacity results. Persons can be reasonably compensated for such injury specific to the diminution of human capital or earning capacity through use of data collected and disseminated by the U.S. Department of Commerce.

I 30

SCIENTIFIC AND LEGAL CRITERIA FOR EVALUATING INJURY CAUSATION FOLLOWING WHIPLASH TRAUMA

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The origin of injury to the cervical spine as a whiplash injury is a common source of dispute in medicolegal circumstances. Determinations of causal relationships between a trauma and an injury in a clinical setting are primarily based on the patient-related history of the traumatic event and the onset of symptoms. However, forensic applications of epidemiology and bioengineering rely on population-based assumptions as a basis for assessing causal relationships. We describe a systematic assessment of specific causation by adapting the established general causation principles of Bradford-Hill in combination with standard epidemiologic investigative techniques for outbreaks. This logical approach to decision-making has become a key component of forensic science. Of the original nine criteria or "viewpoints," a determination of specific causation has been simplified and grouped into two major categories: criteria that answer the question of biologic plausibility "could the exposure have caused the disease?" and those criteria that answer the question of causal association strength "did the exposure cause the disease?" Whiplash injury causation is determined by evaluating relative risk of injury resulting from a given exposure versus competing causes of injury, meaning that the risk of the injury from the event (often a rear-end crash) is compared to the risk that the injury or condition would have happened if the event had not occurred. This is the reason the legal standard for injury or disease causation is the same as the scientific standard, which is the "but-for" criteria, as in "but-for the event in question, would the patient/complainant still have the injury and need for treatment?" The result of this approach is a determination of Probability of Causation (PC). The methodology for quantifying the PC, expressed in terms of "attributable risk percent" of cause is a proportion of injury rates due to the hazard over injury rates with and without exposure to a hazard. Most recently, the criteria for scientific causation have been described as being applied to cases of symptomatic disk derangement following motor vehicle crash trauma (any disc injury including a bulge, herniation, prolapse, etc.). All causal criteria include the following three basic elements: 1) There must be a biologically plausible link between the exposure and the outcome; 2) There must be a temporal relationship between the exposure and the outcome; and 3) Probability of Causation for the suspected cause of the injuries must exceed 50%. This standard of relative risk (also known as the "but-for" standard) of causation is needed to assure uniformity of methods for the evaluation of causation that are acceptable in European courts.

ORAL PRESENTATIONS

O 01

EVARID: A 50TH PERCENTILE FEMALE REAR IMPACT DUMMY FE MODEL

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Introduction: Vehicle crashes causing 'whiplash injuries', is of great concern worldwide. These injuries occur at relatively low velocity changes (Δv), typically < 25 km/h, and in impacts from all directions. Rear impacts are, however, associated with the highest risk and the highest frequency. A number of studies have shown that the whiplash injury risk is higher for females than for males, even in similar crash conditions. Yet, there is only one size of rear impact crash test dummy available – the 50th percentile male (BioRID or RID3D). It does not represent females in terms of mass distribution and dynamic response, and the size corresponds to a ~90th–95th percentile female. Consequently, the existing whiplash protection concepts are more effective for males than females, with 60% risk reduction of permanent medical impairment for males compared to 45% for females. The objective of this study was to start addressing this shortcoming by developing a finite element model of a 50th percentile female rear impact crash dummy, 'EvaRID'. *Materials and Methods:* To establish anthropometric specifications of the 50th percentile female, several sources were assessed, such as anthropometric data from different countries and review of previous publications from the development of the other dummy sizes. The EvaRID V1.0 model was obtained by scaling an existing BioRID II LS-DYNA model. Mass and geometrical dimensions were scaled to obtain values representative of the 50th percentile female. Width and depth dimensions were then established based on scaling of each body segment. Stiffness and damping properties of materials and discrete elements were kept in accordance with the BioRID II model. The EvaRID V1.0 model was evaluated with regard to rear impact tests with female volunteers at Δv 7 km/h, Carlsson et al. (1). The volunteers were selected based on their stature and mass being close to the 50th percentile female. Parts of this work have been published in more detail, Chang et al. (2). *Results and Conclusions:* Until ~250 ms, good correlations were found between the EvaRID V1.0 model and the volunteer tests for head and T1 accelerations and x-displacements, and head angular displacements. The EvaRID model showed markedly less angular motion of the upper thoracic spine in extension compared to the female volunteers. To improve this it will be necessary to adjust the stiffness of the spinal joints. In the future, the EvaRID dummy model has the potential to become a valuable tool when evaluating seats and whiplash protection systems. It may potentially be used as a template for the development of a physical female size dummy. Acknowledgements: This study is part of the ADSEAT project, European Commission, ID 233904. Additional funding was received from the Swedish Transport Agency.

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O 02

LACK OF ENDOGENOUS PAIN INHIBITION DURING EXERCISE IN PEOPLE WITH CHRONIC WHIPLASH ASSOCIATED DISORDERS: AN EXPERIMENTAL STUDY

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Introduction: Evidence for altered central pain processing and central sensitization in chronic whiplash associated disorders (WAD) is accumulating. Dysfunctional descending inhibitory action is one of the major characteristics of central sensitization and has been studied in chronic pain conditions characterized by central sensitization. However, no data regarding the response of people with chronic WAD to exercise are available. A controlled experimental study was performed to examine the efficacy of the endogenous pain inhibitory systems and whether this (mal)functioning is associated with symptom increases following exercise in patients with chronic WAD. In addition, two types of exercise were compared. *Materials and Methods:* Twenty-two women with chronic WAD and 22 healthy sedentary controls performed a submaximal and a self-paced, physiologically limited exercise test on a cycle ergometer on two separate occasions. The exercise tests were undertaken with cardiorespiratory monitoring. Before and after the exercise bouts, subjects filled out questionnaires to assess health status, and underwent pain pressure threshold (PPT) measurements. Throughout the study, subjects' activity levels were assessed using accelerometry in order to monitor potential influences of daily activity levels on exercise performance or symptom fluctuations. Possible changes in any of the outcome measures in response to exercise were compared between the two groups, and between the two types of exercise, using repeated measures ANOVA. *Results:* At baseline, chronic WAD patients presented with hyperalgesia in the lower extremities. In chronic WAD PPTs decreased following submaximal exercise, whereas they increased in healthy subjects. The same effect was established in response to the self-paced, physiologically limited exercise, with exception of the PPTs measured at the calf which increased. A worsening of the chronic WAD symptom complex was reported post-exercise. Fewer symptoms were reported in response to the self-paced, physiologically limited exercise. In addition, no differences in submaximal exercise capacity or daily physical activity were observed between people with chronic WAD and healthy sedentary controls. *Conclusions:* The present study is the first to examine and demonstrate an impaired descending endogenous pain inhibition during exercise in chronic WAD patients, and hence provides additional evidence for the presence of central sensitization in chronic WAD. Although chronic WAD patients' symptoms increased in response to both types of exercise, a self-paced and physiologically limited exercise is more appropriate for chronic WAD patients. Submaximal exercise triggers post-exertional malaise, while a self-paced and physiologically

limited exercise will trigger less 'severe' symptoms and has an additional positive effect by reversing hyperalgesia.

O 03

SELECTIVITY AND VARIATION OF SELF-REPORTED PHYSICAL AND PSYCHOLOGICAL MEASUREMENTS OF PATIENTS WITH CHRONIC NECK PAIN AFTER WHIPLASH TRAUMA – A PILOT STUDY

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Introduction: Patients with whiplash associated disorders (WAD) suffer from chronic neck pain, often followed by generalised pain and cervical dysfunction. They also show a tendency of poorer coping strategies and cognitive functions, suffering from fear of pain, avoidance behavior and traumatic stress, compared to those with chronic insidious neck pain; all risk factors for developing chronic pain, potentially leading to physical inactivity, which influences physical function, general health and quality of life. These aspects make this patient group an inhomogeneous group, which is a challenge in intervention studies as it may weaken the results. Before executing a randomized control intervention study for patients with chronic WAD, we tested the ability to distinguish between WAD and healthy controls by using self-reported measurements, in addition to the ability of using selected of in-/exclusion criteria to create a homogeneous patient group. The aim of this pilot study was: a) to measure whether self-reported physical and psychological function can discriminate between patients with chronic WAD and healthy controls and b) to explore the variation of self-reported measures of patients with chronic WAD. In addition we explored the change in variation of self-reported measures, by excluding patients with depression. *Materials and Methods:* Ten females (mean age 37.7, SD 13.6), with chronic WAD lasting minimum two years and Neck Disability Index (NDI) above 10, compared with 10 matched controls (mean age 35.9, SD 12.5), NDI maximum 5, completed the study. Physical and mental function was measured by SF-36 (physical and mental component scale, PCS and MCS), psychological factors were measured with questionnaires on posttraumatic stress (Impact of Event Scale, IES), depression (Beck's Depression Inventory, BDI), kinesiophobia (TAMPA scale for Kinesiophobia) and fear avoidance of movement (Fear Avoidance Beliefs Questionnaire, Activity and Work, FABQ-A, FABQ-W). Variation was estimated by calculating coefficient of variation (c.v.). *Results:* WAD-subjects reported significantly lower than the matched control group on SF-36 PCS (37.59 versus 57.58, p-value <0.001) and SF-36 MCS (41.23 versus 57.38, p-value 0.004) with a c.v. of 24% and 34%, respectively, as well as on all psychological factors. For WAD-subjects c.v. for IES, BDI, Tampa, FABQ-A, FABQ-W was 69%, 74%, 17%, 38% and 57%, respectively. If BDI below 29 was used as inclusion criteria, c.v. of SF-36 PCS and MCS decreased to 20% and 26%, respectively; while on a whole, c.v. of the psychological factors did not change. *Conclusions:* The selected self-reported measurements were able to distinguish between WAD and matched healthy controls, but still a large c.v. was present in the WAD-group. Supplemental BDI inclusion criteria only decreased c.v. in SF-36 PCS and MCS. Additional inclusion criteria to increase group homogeneity must be considered and further studies of the effect are recommended.

O 04

INEFFICIENT DIFFUSE NOXIOUS INHIBITORY CONTROLS IN PATIENTS WITH CHRONIC WHIPLASH ASSOCIATED DISORDERS: AN EXPERIMENTAL STUDY

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Introduction: Most of the patients involved in a whiplash trauma recover within 3 month (1). However, 10–42% of the patients with acute whiplash-associated disorders (WAD) develop chronic pain (2). A growing body of evidence suggests that abnormal central pain processing accounts for a wide range of symptoms in patients with chronic WAD (3). Enhanced temporal summation (TS) and inefficient endogenous pain inhibition, in particular diffuse noxious inhibitory controls (DNIC), may modulate central pain processing in patients with chronic WAD (4). Neither DNIC on TS of pressure pain nor TS of pressure pain has been studied in patients with chronic WAD. Therefore, the present study aimed at examining: 1) TS of pressure pain; 2) the effect of DNIC on TS of pressure pain in people with chronic WAD. *Materials and Methods:* Thirty-five persons with chronic WAD and 31 healthy controls were subjected to an experiment evaluating TS and DNIC. Temporal summation was provoked by means of 10 consecutive pressure pulses at an upper and lower limb location. Pain intensity of the first, fifth and 10th pulse was rated. The mechanism of DNIC was induced by an inflated occlusion cuff and evaluated by comparing TS prior to and during cuff inflation. *Results:* Temporal summation of pressure pain was demonstrated in groups. A tendency towards a different TS effect between patients with chronic WAD and healthy controls was found at the shoulder prior to cuff inflation. During cuff inflation, TS of pressure pain was significantly different between patients with chronic WAD and control subjects. Resulting powerful DNIC activation, TS effect decreased during cuff inflation in healthy controls. In contrast, TS before and during cuff inflation was quite similar in the chronic WAD group, providing evidence for a deficient DNIC in patients with chronic WAD. *Conclusions:* The present study demonstrates for the first time a lack of DNIC on TS of pressure pain in chronic WAD patients, and hence provides additional evidence for the presence of central sensitization in chronic WAD.

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O 05

NEUROCOGNITIVE AND SENSORY MOTOR DEFICITS ARE AN IMPORTANT SUBGROUP OF WHIPLASH-ASSOCIATED DISORDERS

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Introduction: Neurocognitive and sensory motor deficits are common in whiplash-associated disorders. These are associated with neurological soft signs, body image disturbances, psychological reactions and a poor ability to learn specific motor control exercise. The Motor Control Abilities Questionnaire is an instrument that was developed as a screening tool to predict if people could learn specific motor control exercise. It has been validated for acute and chronic low back pain, and acute and chronic neck pain following whiplash. *Relevance:* The brain competition hypothesis helps explain some of the findings in chronic pain conditions. There is an overlap in the brain where the processing takes place for: coordination, sensory motor function, neurocognitive function, and psychological function. This creates the potential for competition for resources. In a normal brain, resources are allocated effectively. There is only competition when the system is significantly challenged. When there is a deficit in one of these areas, competition may occur for the limited resources. A deficit will occur in one or more areas depending on the prioritization, what is needed at the moment and initial ability to deal with multiple demands. A deficit could manifest as poor coordination, reduced learning or a psychological reaction. These deficits are relevant for a number of reasons. Patients with neurocognitive and sensory motor deficits are less likely to respond to interventions that require skills such as reading, memory, concentration, problem solving and sensory motor awareness. These deficits and related factors are also associated with reduced central inhibition of pain, therefore these patients are more likely to present with central sensitization. These deficits are also associated with body image disturbances so are more likely to have complex pain presentations. Current standard therapy and recommendations from international guidelines do not adequately address these deficits. Clearly, different therapies are needed for this group of patients and they should be considered as a separate subgroup. Evidence is growing for new types of therapies that aim to more specifically target aspects of the central nervous system that influence body image, neurocognitive function and the pain mechanism. These are derived from treatments of children with learning difficulties and conditions associated with body image disorders or central sensitization. Examples will be given for auditory discrimination, oculomotor techniques and primitive reflex inhibition.

O 06

NEURO-OTOLOGICAL CONSEQUENCES OF WHIPLASH TRAUMA: A PHYSIOTHERAPY PERSPECTIVE

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Introduction: Vertigo, dizziness and unsteadiness are the most common and distressing symptoms, the sequelae of whiplash injury. The most frequent forms are: traumatic benign paroxysmal positioning vertigo, phobic postural vertigo, traumatic otolithic vertigo and fistulae. These disorders are well documented in the clinical and scientific literature, reported as early as 1933 by Hasegawa. *Materials and methods:* As physiotherapy clinicians it is very important for us to understand vertigo and dizziness experienced by whiplash-injured patients that may result from peripheral inner ear damage as a consequence of their neck injury – a linear acceleration–deceleration force. Since these patients' vertigo, dizziness and unsteadiness may not be due or only in part due to cervical musculo-skeletal damage and/or psychogenic, a neuro-otological examination is obligatory to exclude peripheral vestibular dysfunction in this clinical population; in particular if the patient is not responding to treatment. *Results:* It is envisaged that by highlighting the neuro-otological consequences of whiplash injury physiotherapists and other health professionals treating these patients will have a broader perspective and understanding of other aetiologies that may be contributing to the patients' dizziness, vertigo and unsteadiness thereby enhancing patient care and reducing the burden of cost to the both the patient and community. *Conclusions:* Dizziness, vertigo and unsteadiness are common sequelae to whiplash injury due to numerous pathologies, some of which are due to peripheral vestibular injury. Therefore, a multi-disciplinary approach is required for the treatment and management of the whiplash-injured patient.

O 07

NECK MUSCLE ACTIVITY AND POSTURAL SWAY DURING DAILY LIKE ACTIVITIES IN PATIENTS WITH CHRONIC NECK PAIN AFTER WHIPLASH TRAUMA COMPARED WITH HEALTHY CONTROLS

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Introduction: Patients with whiplash-associated disorders (WAD) have shown inappropriate patterns of neck muscle activity in response to standardized neck and shoulder–arm tasks, as well as decreased postural balance during static balance. Whether this pattern is found also during more challenging daily like activities, such as unilateral stance and perturbation, is not known. The aim was to investigate neck muscle activity and postural balance, in patients with WAD and healthy controls (CON) during challenging balance tasks. *Materials and Methods:* Ten females (mean age 37.7, SD 13.6) years, with chronic WAD of minimum two years, Neck Disability Index (NDI) above 10, and without brachial neuropathy, and a CON group of 10 age-matched females (mean age 35.9, SD 12.5) years, NDI of maximum five, completed the study. Surface electromyography of the anterior scalene (AS), sternocleidomastoid (SCM), neck extensors (NE) and upper trapezius (UT) muscles was recorded, and for each muscle expressed as % of maximal activity (MVE) recorded during maximum voluntary contraction. Four balance tasks were performed on a force

plate: Romberg stance with open (OE) and closed eyes (CE), unilateral stance (UN), and a perturbation test with sudden unloading. Area of total sway, slow and fast components of sway (rambling and trembling), and range of displacement (anterior-posterior, AP; medial-lateral, ML), were calculated. *Results:* Mean NDI was for WAD and CON 20.6 (SD 7.2) and 0.8 (SD 0.6), respectively. For the three balance tasks mean % MVE for all four muscles was significantly larger in WAD compared to CON (AS: 10.8 vs 7.4; SCM: 11.6 vs 3.6; NE: 20.0 vs 7.0; UT: 6.5 vs 3.3). Significantly larger muscle activity was seen in WAD in all muscles before (WAD: 31.1 vs CON:12.3) and after perturbation (WAD: 25.0 vs CON: 10.5% MVE). Postural balance was significantly decreased in WAD compared to CON during CE and UN (mean areas of CE and UN, in mm^2: total sway 1,302.0 vs 781.7; rambling 866.3 vs 485.95; trembling 225.1 vs 158.9. Range in mm: AP 45.4 vs 36.1; ML 40.8 vs 32.5). *Conclusions:* Compared to CON WAD showed higher relative neck muscle activity during balance tasks, higher relative activity before and after perturbation, and decreased postural balance in challenging balance tasks. This indicates a disturbed sensory feedback and processing in WAD during challenging balance tasks, which may affect performance in daily activities with detrimental consequences.

O 08a

SYMPTOMS AND FINDINGS IN A PROSPECTIVE COHORT STUDY OF THE MISINTERPRETED PATIENT WITH LONG LASTING BENIGN PAROXYSMAL POSITIONAL VERTIGO

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Introduction: Benign paroxysmal positional vertigo (BBPV) is characterized by short attacks of position related rotatory vertigo. Individuals with long lasting dizziness and diffuse symptoms are therefore interpreted as not suffering from BPPV. *Materials and Methods:* A consecutive prospective register study was performed. Sixty-nine individuals (26 with whiplash associated disorders, 30 with a history of head/neck trauma, 13 with no history of trauma) fulfilled the eligibility criteria: 1) BPPV confirmed by video-oculographic documentation of nystagmus in BPPV relevant positions, 2) and positive responses during otolith repositioning maneuvers, 3) symptoms persisting for a duration of at least six months, 4) normal MRI cerebrum. The subjects answered the Dizziness Handicap Inventory (DHI) and a questionnaire concerning possible symptoms of long lasting BPPV. *Results:* The DHI score for all patients was medium high. More than one semicircular canal was engaged in all patients. Dizziness (81%) is far more common than rotatory vertigo (19%). The prevalence of various symptoms as well as the symptoms announced and findings observed during the canalith repositioning maneuvers were registered. There were no significant differences between the study groups. Sixty-nine percent were on long term sick leave. *Conclusions:* The clinical picture of long lasting BPPV is different from the acute BPPV. Diffuse dizziness, blurred vision, frontal headache, neck pain, nausea, sleep disturbances, cognitive difficulties are symptoms found in this patient group. The findings are nystagmus, periorbital spasm and athetonic like neck spasm. The majority of the patients in this study have been diagnosed with phobic postural vertigo. It also includes patients diagnosed with whiplash-associated disorders (WAD) and others who believe they suffer from WAD. The common denominator amongst all these patients is a long lasting BPPV.

O 08b

HAVE WE BEEN FOOLED BY BPPV WHEN DIAGNOSING WAD? ONLY A FEW SEEM TO HAVE A REAL NECK INJURY

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Introduction: The similarities between whiplash-associated disorders (WAD) and traumatic neck disorders with intermittent symptoms constitute the background for many medico legal conflicts. Many symptoms are common among patients with long lasting benign paroxysmal positional vertigo (BPPV) and patients with WAD. Smooth pursuit neck torsion (SPNT) test has earlier been presented as a diagnostic tool. The aim of this study is to 1) find the prevalence of BPPV in the study groups; 2) to validate the SPNT test as a specific test for diagnosing WAD. *Materials and Methods:* A consecutive prospective register study was performed. Patients with long lasting balance disorders are referred to Otoneurology Centre in Southern Norway. These are primarily patients unsuccessfully treated by the public health care. Fifty-six individuals fulfilled the eligibility criteria: 1) neck pain caused by trauma and dizziness persisting for at least six months, 2) normal MRI cerebrum, 3) no severe eye disorders. These patients were allocated in two groups. Twenty-eight patients fulfilled the criteria of WAD and constituted the patient group. Twenty-eight patients with a history of head/neck trauma and intermittent symptoms constituted the control group. Amongst the controls there were patients who believe they suffer from WAD. A healthy control group of twenty-five individuals defined the range of normality. All patients answered the 1) Dizziness Handicap Inventory (DHI), 2) a questionnaire concerning possible symptoms of long lasting BPPV and 3) a visual analogue scale for pain. All subjects underwent an otoneurologic intervention consisting of 1) Clinical Test of Sensory Interaction and Balance (CTSIB), 2) video-oculography for BPPV in Brandt-Daroff as well as Dix-Hallpike position and 3) video-oculography for SPNT test. *Results:* There were no significant group differences concerning the questionnaires and the CTSIB. A BPPV was diagnosed in all patients. More than one semicircular canal was engaged in most patients. The SPNT test was found positive in seven of the patients with WAD and in one of the control group. The sensitivity is found to be 25% and the specificity is 96%. The predictive value as positive test is 88% and as negative test is 56%. *Conclusions:* The investigation shows that BPPV plays a crucial part in WAD. The SPNT test documents a very high specificity. The degree of neck injury probably determines the sensitivity and the predictive values. It is the author´s opinion that the majority of patients diagnosed with WAD in fact suffer from a long lasting BPPV. A minority of these patients suffer from both a BPPV and a neck injury. The SPNT test is most likely an instrument for identifying the real neck injuries amongst the patients with WAD.

O 09

EXPERIMENTALLY INDUCED DEEP CERVICAL MUSCLE PAIN DISTORT HEAD ON TRUNK ORIENTATION

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Objectives: Interaction between vestibular, visual and proprioceptive information secure balance control during performance. Cervical sensory input has a special importance, since it interacts with vestibular input for proper understanding of how the head moves in space and relative to the trunk. Distorted cervical information may be suspected to cause dizziness due to sensory mismatch, under certain circumstances, i.e. cervicogenic dizziness. The disturbed cervical information may also interfere with improper motor commands. Conditions with neck pain may therefore be hypothesized to cause improper sensory input leading to both dizziness and improper motor control. *Aim:* To investigate the effect of experimental muscle pain on head on trunk orientation. Psychometric head repositioning tests makes indirect evaluations possible. *Methods:* We studied the ability to reproduce head positions to two targets (30° of rotation and neutral head position (NHP)) [target position], to both right and left side [side] in eleven healthy volunteers (6 men, 5 women, mean 24 years (range 19–33)) during induced cervical pain. Muscle pain was induced by saline infusion (Natrii chloridum, 50 mg/ml) in paraspinal muscle at C2/3-level, left side, most likely to the splenius muscle. The site was assured by palpation and thereafter by using a hypodermic needle connected to an EMG-amplifier. Measurements were initiated immediately and 15 min after pain induction [pain state]. Head position and hence, repositioning was measured by Zebris©, a 3-D ultrasonic motion analyzer, which consists of a helmet and shoulder cap and measures head relative to the trunk by triangulation. Target positions were introduced by the test leader and then reproduced six times by the volunteer. The volunteer pressed a button connected with the computer of the Zebris system, each time they considered themselves to be at the targets. *Results:* Directly after pain was induced, accuracy for head on trunk repositioning was reduced for the 30° target on the side where pain was induced (p-value 0.032) but not on the other side (p-value 0.759). The GLM Univariate Analysis of Variance model indicated a significant interaction before and directly after pain induction, between target position, side and pain state (p-value 0.001). There was a significant interaction before and after 15 min between target position, side and pain state (p-value 0.033) and an interaction between target position and pain state (p-value 0.002). *Conclusion:* Experimentally induced pain distorts the cervical position sense resulting in less accuracy for movements toward the ipsilateral side. The effect of impaired repositioning ability was not seen for movements toward the other side. This indicates a specific change in the sensorimotor control, after inducing muscular pain and there seems to be an interplay between pain and impaired head orientation. Head on trunk orientation could consequently be affected by cervical pain and could thus be one possible cause for both sensory mismatch with cervicogenic dizziness and impaired cervical sensorimotor control.

O 10

PROSPECTIVE VS. RETROSPECTIVE ASSESSMENT OF TEMPOROMANDIBULAR JOINT DISC DISPLACEMENT AFTER WHIPLASH TRAUMA: DIFFERENT OUTCOMES

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Introduction: Magnetic resonance (MR) imaging studies on temporomandibular joint (TMJ) pathology following whiplash trauma have to date typically been retrospective in design and based on patients' memory for onset of their TMJ problems. The objective of this report was to compare the frequency of TMJ disc displacement as assessed in retrospective studies versus that of a prospective study. *Materials and Methods:* The retrospective part comprises a literature review. The prospective part included 60 consecutively admitted patients with neck symptoms after rear-end car collisions. The patients underwent bilateral MR imaging of their TMJs within 3–14 days after the collisions. *Results:* The retrospective studies reported a frequency of whiplash-associated TMJ disc displacement ranging from 56% to 87% while conversely the prospective study failed to reveal any whiplash-induced TMJ disc displacement. *Conclusions:* The discussion will bring to light recent data, which explains the vast difference in results between the prospective and retrospective studies.

O 11

15-YEAR PROSPECTIVE FOLLOW-UP OF TEMPOROMANDIBULAR JOINT SYMPTOMS AND MR FINDINGS IN INDIVIDUALS EXPOSED TO WHIPLASH TRAUMA

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No abstract available.

O 12

IMMOBILIZATION OR MOBILIZATION IN ACUTE NECK TRAUMA PATIENTS

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Introduction: There has been considerable debate concerning the treatment of symptomatic patients after acute cervical trauma with cervical collars and braces. Several studies have condemned the soft cervical collars routinely prescribed as not only ineffective but as counterproductive to the rehabilitation and healing process particularly in cases with mild symptoms and no objective findings. However, more severe trauma with high pain levels and suspected serious pathology may require a period of immobilization followed by mobilization. This presentation will present the evidence for and against immobilization/mobilization and suggested research for the study of these treatment options for patients with neck injury after trauma.

O 13

CASE REPORT: SYMPATHETIC NERVOUS ACTIVITY WITH SEVERE MUSCULAR DYSFUNCTION AND PAIN THAT WAS MODERATED BY ZYGAPOPHYSEAL BLOCKS AND GANGLION IMPAR BLOCKS

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Introduction: Symptoms of autonomic activity is often seen among pain patients. Different kinds of sympathetic nervblocks is said to modulate this but not much is written about the possibility that sympathetic symptoms can be revealed by treating the pain-generators. *Materials and Methods:* Case report of a patient treated 15 years after a whiplash-trauma. *Results:* A 41-year-old healthy woman was involved in a head-on accident. Starting with pain in neck, head and right arm a totally devastating syndrome evolved including widespread pain combined with severe muscular dysfunction. When the pain was trigged clonic-tonic convulsions started regionally and then spread to her entire body. During the convulsions she was awake but unable to control her body. These attacks came several times a day which forced her to have a personal assisting nurse at standby 24/7 to assist her if necessary. All kinds of treatments were tried without result before she came to us 14 years after the accident. Our first aim was her low back pain. The diagnostic tests, medial branch blocks (MBB), trigged convulsions but with short duration. As she was pain free in the lumbar region and leg during repeated blocks we decided to make a radio-frequency (RF) lesion of these nerves. Six month later her pain was reduced to 50% but there were signs of raised autonomic symptoms from the leg. We then decided to make a ganglion impar block. The result of this was that long-lasting convulsions were trigged. The assisting nurse told us that these kinds of convulsions normally kept on for several days. The muscular convulsions in the face with slow progrediation of the spasm looked somewhat similar to those seen in another patient with problems from the facet joints in the neck. We therefore decided to make MBB at cervical level, C2–C4. When the local anaesthetic started to act the convulsions disappeared. The same tests were repeated (MBB C2–C4 and ganglion Imparblock) two more times with similar results. We then made a RF denervation at level C2–C4. After this no general convulsions has been seen although focal muscular contractions can still appear, mainly in arm and face although reduced in frequency. *Conclusions:* Is this a psychological syndrome? We think not. Based on the known rich sympathetic innervation of the facet joints, the spino-thalamic route for sympathetic innervation and muscular dysfunctions associated to sympathetic nervous activation as seen in CRPS we believe that this is a somatic pain-syndrome with unusual symptoms. Our interpretation is that she had a pain-syndrome involving facet joints with secondary sympathetic activation seen as both typical symptoms like coldness, swelling, sweating, etc but also in the form of severe muscular dystonia/convulsions. Ganglion impar block or the medial branch blocks disturbed the balance and hence trigged convulsions. But when both were anaesthetized the route was blocked and the convulsions stopped.

O 14

PAIN NEUROPHYSIOLOGY EDUCATION IMPROVES COGNITIONS, PAIN THRESHOLDS AND MOVEMENT PERFORMANCE IN PEOPLE WITH CHRONIC WHIPLASH: A PILOT STUDY

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Introduction: Chronic whiplash is a debilitating condition characterized by increased sensitivity to painful stimuli, maladaptive illness beliefs, inappropriate attitudes, and movement dysfunctions. Previous work in people with chronic low back pain and chronic fatigue syndrome indicates that pain neurophysiology education is able to improve illness beliefs and attitudes as well as movement performance. Although the use of psychoeducational interventions has been studied in patients with whiplash-associated disorders (WAD), the use of pain neurophysiology education in patients with chronic WAD has not been examined previously. Therefore, the present pilot study aimed at examining whether education about the neurophysiology of pain could alter pain beliefs and behavior, symptom severity, daily functioning, pain threshold, and movement performance in patients with chronic WAD. *Materials and Methods:* Six chronic WAD patients participated in a single-case study with A-B-C design spread over 8 weeks. Periods A and C represented assessment periods, at which patients filled out a battery of questionnaires i.e. the Neck Disability Index (NDI), the WAD Symptom List, the Pain Catastrophizing Scale (PCS), the Pain Coping Inventory (PCI) and the Tampa Scale for Kinesiophobia (TSK). Patients were also subjected to a set of clinical assessments i.e. the Neck extension test, the Brachialis Plexus Provocation Test (BPPT) and algometry. The NDI and the pain pressure thresholds (PPTs) were chosen as the primary outcome measures. At period B the chronic WAD patients received the intervention which consisted out of two one-on one education sessions and an information leaflet about the neurophysiology of pain. The treatment effect was examined using a Wilcoxon signed ranks test and Cohen's d effect sizes (ES) were calculated. *Results:* Results showed a significant decrease in kinesiophobia (TSK $p = 0.03$, 18.3% improvement, ES = 0.82), the passive coping strategy of resting (PCI subscale resting $p = 0.03$, 18.3% improvement, ES = 1.29), self-rated disability (NDI $p = 0.046$, 17.7% improvement, ES = 0.46), and photophobia (WAD Symptom List VAS photophobia $p = 0.04$, 33.8% improvement, ES = 0.34). At the same time, significantly increased PPTs (at the trapezius $p = 0.03$, 33.3% improvement, ES = 0.57 ; at the calf $p = 0.04$, 25.5% improvement, ES = 0.42) and improved pain-free movement performance (VAS Neck extension test $p = 0.04$, 43.5–59.2% improvement, ES = 1.04–1.16; VAS BPPT $p = 0.04$, 60% improvement, ES = 1.45) were established. *Conclusions:* Chronic WAD is a debilitating and costly condition, and treatment remains challenging for clinicians, including rehabilitation specialists and physiotherapists. Because very few trials have evaluated conservative interventions for patients with chronic WAD, clinical studies examining the effectiveness of conservative

treatment strategies are required. Changing inappropriate pain beliefs should be the initial phase of rehabilitation in those with chronic WAD. If not, poor understanding of pain may lead to the acquisition of maladaptive attitudes, cognitions, and behavior in relation to pain and subsequent poor compliance to any active treatment. Although the current results need to be verified in a randomized, controlled trial, they suggest that that rehabilitation specialists and physical therapists are able to influence negative thoughts and pain behavior by educating patients with chronic WAD about the neurophysiology of pain. The improvement in pain behavior resulted in improved neck disability and increased pain-free movement performance and pain thresholds.

O 15

"TRIGGER POINT" SURGERY FOR SOFT TISSUE PAIN IN CHRONIC WHIPLASH SYNDROME

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By default, unremitting and seemingly therapy resistent neck pain and associated symptoms precipitated by acute whiplash trauma, is an expression of pathology that may be associated with injury to the spine, or to extra-spinal structures, or both. While the relative importance of the various explanatory models has not been conclusively established, soft tissue injury is not infrequently described as an important and potentially predominant reason for pain, stiffness, and other components of the chronic whiplash syndrome. The precise anatomical origin of symptoms in chronic whiplash can rarely be determined with exactitude by physical examination, while imaging studies and other routine laboratory investigation commonly is of limited value except to exclude gross spinal or central nervous pathology. Therefore, surgical treatment in chronic whiplash is, to a certain extent, dependent on intraoperative patient feed-back for adequate identification and excision of individual pain generators. With reference to a collective experience of approximately 2,000 interventions, performed under intermittent anesthesia for soft tissue pain in chronic whiplash, the authors will discuss indications, anesthesia techniques, and intraoperative findings, as well as research data from individual studies illustrating outcome of treatment for up to four years after surgery.

O 16

DOES COMPENSATION LEAD TO WORSE HEALTH, OR DOES WORSE HEALTH LEAD TO COMPENSATION? WHY BOTH POSSIBILITIES MUST BE CONSIDERED

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Introduction: A maintained hypothesis – that compensation is a cause rather than a consequence of poor health – exists in the health literature. The assumption that a unidirectional, causal pathway runs from compensation to health outcomes leads some to believe that negative correlations, when observed, are confirmation that compensation is harmful to health. We contend that the relationship between compensation and health outcomes is more complicated than one is often led to believe. In short, we suspect that the causal pathway between compensation and health is bi-directional, and therefore, testing whether compensation has an effect on health is hampered by the fact that compensation is also determined in some way by health. *Materials and Methods:* We use survey data obtained from individuals with whiplash to demonstrate the importance of considering both possible causal pathways when testing whether compensation leads to worse health. We compare the result obtained when the "usual" approach to multivariate regression is applied, with the result obtained when bi-directionality is addressed. *Results:* We find statistically significant evidence of endogeneity, and a substantial difference in the coefficients observed in the two approaches. *Conclusions:* The inclusion of covariates with unclear or simultaneous causal pathways (such as compensation) in multivariate regression analyses will yield effect estimates that are likely to be either over- or underestimated, and will fail to represent the true relationship between the variables of interest. This study demonstrates that health and compensation are endogenous, and that this problem must be addressed in order to avoid a biased result.

POSTER PRESENTATIONS

P 01

POSITIONAL CERVICAL SPINAL CORD COMPRESSION AS A COMORBIDITY IN PATIENTS WITH FIBROMYALGIA: FINDINGS FROM A ONE-YEAR RETROSPECTIVE STUDY AT A TERTIARY, FIBROMYALGIA REFERRAL UNIVERSITY

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Introduction: At ACR2007, positional cervical spinal cord compression (PC3) documented by dynamic MRI from positional disc and ligamentum flavum distortion was described as a common comorbidity among patients with fibromyalgia (FM). This study was conducted to evaluate those observations at an independent, second research site. *Methods:* Sagittal flexion and extension images with measurement of the cervical canal diameter at each disk level were added to a traditional C-spine MRI protocol (described in J Pain 2008; 9 (7): 613–622) available for patients with FM referred to our institution. The dynamic MRI was generally offered to FM patients with severe cervical pain with extension. A retrospective chart analysis of all FM patients seen during 2007 was assessed for the prevalence and examination characteristics of patients of FM with PC3. PC3 was defined as radiographic documentation of abutment and/or compression of the cervical spinal cord with a canal diameter of < 10 mm (normal 13–15 mm). *Results:* Of 380 patients seen for evaluation of FM, 129 patients (9 men, 120 women, mean age 48.1 years [range 20–70 years]) with FM by full ACR criteria received a dynamic MRI in the course of treatment. 61 FM patients (47.3%) had PC3 as defined above, although 57.4% had narrowing of the cervical spinal canal below 9.5 mm. Two patients had a Chiari malformation (1.6%). The extension, sagittal view was required for documentation of spinal cord compression for 40/61 (67%) with FM+PC3+. The standard neutral sagittal MRI was insensitive for PC3, consistent with previous reports. Most common disc herniations were C5–6 (38/61), C4–5 (21/61), C6–7 (15/61) and C7–T1 (2/61). Most PC3 patients had single level compressions (61%), while 31% had two levels and 8% had three levels. Although treatment with a developing physical therapy protocol was most common, 11 of 61 (18%) patients with PC3 required surgical decompression. Clinical examination features included positive Romberg test (balance insecurity with eyes closed, 49.6%), Hoffman test (25.9%), Beighton hypermobility score ≥ 5/9 (37.3%), reflexes (normal 37.5%, hypo-reflexive 14.8%, hyper-reflexive 46.7%), documented obstructive sleep apnea (48.1%) and cervical pain with extension (93.1%). Pearson correlation and Chi-square analysis revealed a strong association with compression and positive Romberg ($p < 0.001$), but not with other examination assessments. *Conclusion:* These findings independently support previous reports of PC3 as a common finding among FM patients, that neutral MRI evaluation of the cervical spine has inadequate sensitivity for this anatomical finding and that specific clinical correlations with PC3 remain elusive and uncommon in patients who present with FM.

P 02

REDUCE OF HEAD INJURIES DURING WHIPLASH BY THE HELP OF MATERIALS WITH INDEPENDENT STRAIN RATE

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Introduction: The main aim of this article is to demonstrate energy absorbing materials for the headrest productions, which can bring a reduction of neck and head injuries. Whiplash injuries can be caused by intense deceleration of the head during impact to headrest. To address this serious problem, it would be ideal to have gradual deceleration of the head on adequately long trajectory. This can affect and reduce the value of HIC (Head Injury Criterion) and also it can reduce the energy of the head impact HIP (Head Impact Power). With respect to a headrest design, the main cause of injury can be incorrect headrest geometry or unsuitable material used for the comfort and safety layer. Currently, soft polyurethane foam (PUF) is the most common used material for headrest production. The disadvantage of PUF is variable stiffness, which increases with strain rate. The cause of this phenomenon is usually explained by the influence of air, which is inside the cell structure and during fast compression it can not escape fast enough. Improvement of existing features of headrests and elimination of the mentioned problems would be possible by use of suitable material with the strain rate independent properties. Such material can be made of fibrous structures. Its porosity and consequently the permeability is significantly higher and therefore stiffness is almost independent of the strain rate. Contact pressure and compression stress of the material of PUF is significantly different during dynamic impact compare with fibrous material. This was confirmed by experimental measurements and also by help FEM simulation of Whiplash IIWPG 16 km/h in accordance with EURONCAP methodics. *Materials and Methods:* In the experiment, two samples with different structures were used. The sample A was standard flexible PUF, which is normally used for car seat headrests. The sample B was created from recycled fibres with horizontally laid structure bonded by heat. The dimensions of samples were $100 \times 100 \times 50$, 40, 30 mm. Used samples were tested for energy absorption using the free fall test. Different shapes of probes (plane, sphere) with a average mass 5.3 kg were used. Their weight were calculated in accordance with the shape of the human head geometry based on statistical Zaciorskij method. Time and force of the impact were measured. The velocity and trajectory of probes during the free falling test was captured by the help of high speed camera system Aramis. From obtained results the material stiffness depending on time was calculated. Other necessary parameters were obtained by a quasi-static cyclic loading. Material parameters were used for FEM simulation of the headrest from PUF and recycled fibre material. The simulation of the whiplash was performed in software PAM- CRASH. *Results:* Results of dynamic tests, which are shown in figures, exhibit an influence on energy dissipation and consequently different damping during the impact of the head to backrest. The dissipation of fibrous

sample was about 16%, in the case of PUF it was about 27%. These differences can be given by the characteristic of PU foam, which exhibits higher stiffness, which increases with decreasing thickness (50, 40, 30 mm). The HIC value of fibrous structure was about 20% lower compared to PUF sample. *Conclusions:* The results of simulation exhibit significant influence of stiffness on strain rate in the case of PUF. It is evident that suitable material produced from fibres can reduce a neck and head injury.

P 03

HUMAN CENTRIFUGE HIGH ACCELERATION (G) TRAINING INJURY – A WHIPLASH-ASSOCIATED DISORDER

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Introduction: Fighter pilots encounter severe physical stress due to high acceleration (G/Gravity) during air combat and aerobatic maneuvers. The physical effects include sagging of soft tissues, increased weight of head and body, and compression of spinal column. Helmet mounted with optical devices that pilot dons commonly weighs over 2.5 kg. This adds to the cervical stress. It creates mechanical problems as it alters the centre of gravity of the head and its acceleration magnified weight further stresses the cervical spine. Other physical effect includes amplified hydrostatic gradients in the cardiovascular system. During dominant acceleration, blood is forced to pool from the head to toe direction. Although Anti-G suit helps counteract this circulatory effect, over 10% of fighter pilots reported experiencing unexpected acceleration induced loss of consciousness (G-LOC) while flying aerobatic maneuvers. These potential safety hazards similarly occur in human centrifuge machine that produces repeatable high acceleration training for pilots. It is a machine with rotating arm at the end of which is a capsule in which the pilot sits. It generates an environment of G stresses similar to that in fighter aircrafts. Whiplash is classically an acceleration-deceleration neck injury following motor vehicle collision. Neck pain is the predominant symptom. Additionally, there may be a constellation of other clinical manifestations. Quebec Task Force adopted the term whiplash-associated disorder (WAD) to describe this syndrome. *Case Report:* A 34-year-old male fighter pilot had history of occasional neck stiffness and monthly episodic migraine headache. A week before consultation, he sustained a human centrifuge training injury. At 9G, he had 2 transient episodes of G-LOC. He regained consciousness with his head dropped down towards chest. He had left neck and upper thoracic constant sharp pain. It did not radiate down his limbs. The Numerical Pain Intensity was 8 on a scale of 0 to 10. Left scalene, upper trapezius and parathoracic erector spinae were taut and tender. Cervical spine end range of motions was limited by pain. Neurologic examination was essentially normal. MRI cervical and thoracic spines were normal. Subsequent weeks, he had increasing episodes of migraine attacks, as frequent as alternate days. Sleep and concentration were affected. He was tired. He was treated for WAD grade 2. Traction and mobilization only gave temporary relief. Trapezius stretch, extension and imagery exercises were helpful. He had dry needling of his left upper quadrant muscles. Naproxen 500 mg daily and muscle relaxant were prescribed to improve sleep. His symptoms improved over the next 4 months. However, he had not regained his flying status. *Conclusions:* G-LOC and neck injuries are adverse events during high acceleration training. Neck protection devices, perhaps in the form of inflatable collar that still allows head mobility when required, may reduce helmet loading stress, vibration forces during flight, and further strains from dynamic head movements during unexpected acceleration. Neck exercises to rebalance and strengthen cervical muscles, together with optimization of neck biomechanics and ergonomics, may reduce risk of neck injury and help maintain the valuable flying status of fighter pilots.

P 04

WHIPLASH INJURIES FOLLOWING ROAD TRAFFIC CRASHES IN A DEFINED POPULATION DURING 2000–2009

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Introduction: The annual incidence of traffic-related whiplash injuries in the western world has increased over the last 30 years and is estimated to be >300 per 100,000. No hospital-based epidemiological studies on whiplash injuries have been published during the recent years. However, rough estimates from the Swedish Insurance Federation indicate that the reported cases of whiplash injuries may have decreased from over 30,000 in 2003 to about 16,000 in 2008. The aim of this study was to perform a thorough examination of the annual incidence rate on road traffic whiplash injuries in our geographical catchment area during the last decade (136,600 inhabitants in December 1999 and 144,500 in December 2009). *Materials and Methods:* We analyzed the Umeå University Hospital's ongoing injury register (10,000 cases/year). On arrival at the emergency department (ED) the injured person was asked to answer a questionnaire about the circumstances of the injury incident. Data was also retrieved from ambulance personnel, bystanders and relatives. In some cases supplementary details were retrieved by interview during the recovery phase. Data from all available medical records and in some cases police reports were included in the data set. During 2000–2009, 15,506 vehicle-related injury events (individuals of all ages) occurred. Those who were subject to a neck injury within whiplash-associated disorder (WAD) 1–4 were included. The overall and annual incidences were calculated as incidence rates. *Results:* During the 10-year study period, 3,357 cases of whiplash injury occurred, 51.4% among women and 48.6% among men. Car crash was the most common type of injury event (86.0%) followed by bicycle crash (6.2%), bus crash (1.5%) and moped crash (1.5%). The overall incidence rate was 235/100,000/year. The annual incidence rates of whiplash injuries seemed to increase slowly from an average of 220/100,000/year in 2000–2004 to 258/100,000/year in 2005–2009. *Conclusions:* ED-visits due to whiplash injuries following road traffic crashes have been slowly increasing during the past decade in our area – contradictory to the data from the insurance industry.

P 05

WHIPLASH INJURIES IN A DEFINED POPULATION – 5-YEAR FOLLOW-UP OF THE NEED FOR SICK LEAVE AMONG MOTOR VEHICLE OCCUPANTS

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Introduction: Whiplash injuries constitute a major health problem and a large economic burden to society. The latest annual incidence from our area was 320 per 100,000 in 1997–1998. The total cost (forever) for all whiplash-injuries in Sweden 2001 has been estimated to 550 million USD. The aim of our study was to describe the number of whiplash injuries during 2001 and the need for sick leave during 2001–2006 among 18–64-year-old motor vehicle occupants in a well-defined geographical area with a population of 86,700 inhabitants. The cost of lost productivity was estimated. *Materials and Methods:* We analyzed the Umeå University Hospital's injury register (10,000 cases/year), patient questionnaires, medical records and the personal files from the local social security office. All patients involved in a car-, bus- or truck-crash within the hospitals catchment area that were found to have whiplash-associated disorder (WAD) 1–4 upon arrival at the hospital were included. Information about sick leave was available from the fifteenth day. Part time sick leave was recalculated into whole days. The authors, to ensure a uniform interpretation, reevaluated all clinical data. The mean cost for one employee in Sweden during 2001 was 52,216 USD (exchange rate as of 2010-01-31). *Results:* The number of cases was 300 (346/100,000/year). Median age was 31 years; 56% ($n=169$) were men and 44% ($n=131$) were women. Seventeen per cent ($n=51$) took sick leave for more than 14 days; 18% of the men ($n=30$) and 16% of the women ($n=21$). The mean length of sick leave was 672 days; median 328 days; range 15–1,825 days. The total number of sick leave days was 34,266 or 94 years. The cost to society of lost productivity was estimated at nearly 5 million USD for this cohort during the 5-year follow-up. *Conclusions:* Whiplash injuries are common and constitute a large economic burden to society.

P 06

HEALTH CARE CONSUMPTION BEFORE AND AFTER NECK TRAUMA – POPULATION-BASED OBSERVATIONAL DATA FROM SWEDEN

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Introduction: There is limited knowledge of the health care seeking patterns of patients after trauma to the neck. The aim of this study was to describe the health care consumption before and after neck trauma using population-based observational data. *Materials and Methods:* In Sweden, all residents have the right to free health care (a small co-pay apply). By law, all patients treated in outpatient- and inhospital care are registered by their personal identification number. We retrieved data from the Skåne Health Care Register which covers the health care provided in the Skåne county (1.2 million inhabitants) in the very south of Sweden. Register entries include the physicians' ICD-10 diagnoses, as well as other information from consultations with professionals in health care. The data was linked to the Swedish population register via the unique personal identification number. Hence, we identified all adult Skåne residents (≥18 years) who in 2006 had received the diagnosis sprain or strain of the cervical spine (S13.4), and who did not have a record of this diagnosis the two previous calendar years. For these individuals, we studied the overall number of clinic visits to physicians or physiotherapists in outpatient care from the calendar year before until two calendar years after the year of neck trauma. *Results:* We identified 1,276 adults (56 % women) who in 2006 were diagnosed with neck trauma, ICD-10 code S13.4 (subjects were all free of the diagnosis the two previous calendar years). This corresponds to 0.15% of the adult population. The peak consultation rate due to neck trauma was seen in women aged 35–39 (data not shown). Women also had more frequent consultations with physicians and physiotherapists, both before and after the neck trauma. The calendar year of the trauma the median number of doctor consultations (5th and 95th percentile) for women and men was 6 (1, 23.5) and 4 (1, 19.9), respectively. The mean number of consultations with physicians was in the calendar year before the neck trauma (women/men) 3.0/2.3, in the calendar year of the trauma 8.4/6.3, in the first calendar year after the trauma 6.9/4.8, and in the following calendar year 3.4/2.2. The mean number of consultations with physiotherapists was in the calendar year before the trauma (women/men) 1.3/0.8. In the calendar year of the trauma 4.8/3.2, in the calendar year after the trauma 4.3/2.8, and in the following calendar year 1.9/0.6. *Conclusions:* Women have more frequent health care consumption before and after neck trauma than men. The increased consumption after trauma mainly consists of doctor consultations, but also an increased number of visits to physiotherapists. Population-based health care datasets may provide novel opportunities in the study of the burden on society and patient after neck trauma.

P 07

SOCIO-DEMOGRAPHIC AND CLINICAL FACTORS AS PREDICTORS TO PSYCHOSOCIAL/ BEHAVIORAL FUNCTIONING AND DISABILITY OF PATIENTS WITH NECK DISORDERS VS. FIBROMYALGIA DIAGNOSES

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Introduction: Most persistent pain patients benefit from interdisciplinary pain rehabilitation programs. Individual, social and economic gains have been documented. Pain-related consequences are more important than specific pain diagnoses for decision about rehabilitation. However, the field asks for more information on diagnoses, treatment effectiveness, and identification of factors associated with treatment effects. *Aim:* The aims of this study were to evaluate: 1) Associations

between socio-demographic factors and patients with neck disorder (ND) vs fibromyalgia (FM); 2) Associations between psychosocial and behavioral functioning and disability of patients with ND vs FM; 3) Outcome associations at one-year follow-up, after pain program, for patients with ND vs FM; 4) Whether socio-demographic factors are predictive for being in ND vs FM group. *Method:* 273 consecutive patients undergoing a pain rehab program. Eighty-two percent women, 40 years, 55% ND and 45% FM, 37% at work to some extent at admission and 75% on sick-leave, 86% Nordic born, 22% secondary school, 63% upper secondary school, 15% university education, 75% married or cohabitating, and 4.2 years pain duration. The teams included physicians, OTs, PTs, psychologists, and social workers. Pain rehabilitation was administrated following CBT principles. Measurements used were Multidimensional Pain Inventory (MPI), Disability Rating Index (DRI) and screening forms. *Results:* Significant differences between FD vs ND were found on sex, age, educational level and pain duration. ND included more males (28% vs 6%), were younger (39 vs 42 years), had higher educational level (19% vs 10% university and 65% vs 60% upper secondary school), and lower pain durations (3 vs 5.5 years). No differences on vocational status, ethnicity or civil status. No differences on psychosocial functioning at admission or at the one year follow-up were found between the diagnosis-related groups. ND patients had significantly lower general activity level, at admission (2.2 vs 2.5) and at one year follow up (2.4 vs 2.7). On the individual items of the DRI index, ND described themselves as more disabled (sitting) and less disabled (running). At one-year follow-up there was significant differences on disability, ND (running) being less disabled ($p < 0.009$). No significant differences of change scores at one-year follow-up were found between the groups. Males had 6.5 increased risk of being ND, patients, younger than 40 had a 1.8 increased risk of being ND, and those with upper secondary school had a increased risk of being ND. *Discussion:* This study confirms that patients with neck disorder more usually are males, younger, with higher educational levels and lower pain duration than fibromyalgia patients. No difference on psychosocial functioning was found between the groups, but patients with ND have lower levels of general activity. Activity item of DRI seems to be perceived differently by NDs and the FMs, differences going to opposite directions.

P 08

INFLUENCE OF SENSORIMOTOR INCONGRUENCE IN PATIENTS WITH CHRONIC WHIPLASH ASSOCIATED DISORDERS: AN EXPERIMENTAL STUDY

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Introduction: Most of the patients involved in a whiplash trauma recovers within 3 month (1). However, 10–42% of the patients with acute whiplash-associated disorders (WAD) develop chronic pain (2). Patients with chronic WAD frequently present impaired sensorimotor control (3) which may induce a conflict between motor activity and sensory feedback. Furthermore, sustained sensorimotor incongruence may act as an ongoing source of nociception inside the central nervous system. A sensorimotor conflict exacerbates pain and sensory perceptions in patients with fibromyalgia (4), suggesting a possible aetiological role for sensorimotor incongruence in the development of (chronic) pain. The purpose of this study was 1) to examine whether a sensorimotor conflict triggers sensory changes in persons with chronic WAD and 2) to investigate whether a sensorimotor conflict contributes to chronic whiplash pain. *Materials and Methods:* Thirty-one persons with chronic WAD and 35 healthy controls performed a bimanual coordination task simulating sensorimotor incongruence. All participants were asked to flex/extend both arms in a congruent/incongruent manner viewing a whiteboard or mirror. Sensory changes were reported and rated after each stage of the protocol. *Results:* A significant difference in experienced sensory changes was found between subjects with chronic WAD and control subjects. Control subjects experienced significantly more sensory changes during the stage with the highest level of sensorimotor incongruence (performing incongruent movements viewing the mirror) compared to the other stages. In contrast, no difference in experienced sensory changes was found between the different test stages in the chronic WAD group. The results revealed that disturbing visual input (e.g. via hiding a moving limb) was sufficient to provoke/exacerbate sensory changes in people with chronic WAD. *Conclusions:* The present study demonstrates exacerbation of sensory changes in patients with chronic WAD as result of disturbed visual input rather than induced sensorimotor conflict. Prolonged disturbance of sensory input may provide an increased nociceptive input to the central nervous system and maintain the chronic WAD process.

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P 09

CAN RECORDING OF REFLEXIVE EYE MOVEMENTS HELP TO OBJECTIFY THE IMPAIRMENTS OF CHRONIC NECK PAIN PATIENTS?

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Introduction: Determination of the severity of complaints of patients with chronic traumatic and non-traumatic neck pain is difficult because of its multifarious nature. Clinical assessment is either based on functional impairments (e.g. diminished range of motion (RoM), loss of strength) or on subjective symptoms like pain, fatigue and diminished concentration. Especially subjective symptoms like disturbances in postural stability, eye movement control and diminished concentration are difficult to quantify objectively. However, neurophysiologic developments may provide a method to quantify these 'sensorimotor symptoms'. In

previous studies it was hypothesized that sensorimotor dysfunction may be caused by altered proprioception in the cervical spine. Although straightforward measurement of proprioception is still not possible, neurophysiologic research revealed that the cervico-ocular reflex (COR) receives sensory input from neck proprioception. Changes in COR are likely to reflect changes in neck proprioception. Our hypothesis is that reflexive eye movement measurements can assist to make the connection between functional impairments and symptoms for chronic neck pain patients. Recording of eye reflexes might help to objectively assess the severity of complaints of neck pain patients. *Background:* The gain of eye reflexes between acute WAD patients and asymptomatic controls were compared earlier (Montfoort et al., 2006). A significant increase of the gain (eye velocity divided by visual stimulus velocity) of the COR in WAD patients was found without the normal adapting response of the vestibulo-ocular reflex (VOR), resulting in suboptimal eye stabilization. Montfoort et al. state that impaired motion of the cervical spine, altered proprioception of the cervical spine or disorganization in the process of VOR plasticity could be reasons for the insufficient change of the VOR. The a-synergy of COR and VOR might cause visual mismatching, resulting in symptoms like dizziness, reading difficulties and loss of concentration. *Objective:* The main goal is to develop an objective symptom profile of chronic neck pain patients which addresses more facets of the health problem, including sensorimotor dysfunction. The first stage is the establishment of an objective quantification of sensorimotor dysfunction. *Methods:* A vast and heterogeneous group of neck pain patients will be assessed using the method of Montfoort et al. The gain of the eye reflexes will be matched to the complaints of the patients. The gain of the three essential eye reflexes (*COR, VOR and OKR*) and the cervical functionality (*RoM, strength*) and impairments (*VAS, SF36, Neck Disability Index and EQ-5D*) are compared in three groups: 1) traumatic, 2) non-traumatic chronic (> 3months) neck pain patients and 3) healthy controls (aged 18–60). *Call:* Interested in participation in the project? Good ideas to improve the design? Any important aspects missing?

P 10

INCIDENCE OF PELVIC GIRDLE PAIN IN CHRONIC NECK PAIN PATIENTS: COINCIDENCE OR NOT?

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Introduction: Chronic neck pain (CNP) is usually approached as an isolated problem. However, many patients with CNP also report symptoms in the thoracic, low back or pelvic region. In the literature there is little information on the relation between CNP and other physical problems. A first step in exploring the relationship between CNP and other physical problems is to investigate their co-occurrence. Especially, the combination of CNP and PGP is interesting, since clinically PGP is frequently reported in combination with both traumatic and non-traumatic CNP while their etiological relation is unclear. In this first study, the prevalence of PGP in individuals with traumatic and non-traumatic CNP is evaluated. *Materials and Methods:* In 2009–2010, 134 seriously impaired and therapy-resistant patients with CNP were directed to a Dutch rehabilitation clinic: the Spine & Joint Centre. All patients had complaints of neck pain for more than three months: average duration of complaints was 5.2 (SD 7.2) years. The patients had no serious structural pathology. Patients were considered positive for PGP when all following tests were positive (score > 2): Active Straight Leg Raise (ASLR) test, Posterior Pelvic Pain Provocation (P4) test and Ligamentum Dorsal Longus (LDL) test. *Results:* Results of all 134 patients were included in this study. 49% of all patients developed CNP after a car accident (traumatic), 14% after other causes and in 37% of the patients the cause was unknown (non-traumatic). The prevalence of PGP in individuals with CNP due to a car accident was 64% and 59% in those with non-traumatic CNP. Confounding factors (such as sex, age) were not significantly different between patients of the traumatic and non-traumatic group. *Conclusions:* Although the major part of CNP patients (61%) also suffers from PGP, the prevalence of PGP is not significantly higher in patients with traumatic CNP compared to the non-traumatic patients ($p = 0.06$). This is due to the fact that PGP also occurs in a considerable part of the non-traumatic CNP patients (59%). Apparently there is a complex relationship between CNP and PGP which can not be explained by trauma only. Consequently further research is necessary to understand the relationship between both traumatic and non-traumatic CNP and PGP.

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BALANCE PROBLEMS AND SOMATIC SYMPTOMS HAD INCREASED 12 YEARS AFTER A WHIPLASH INJURY

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Introduction: The background consists of 130 whiplash patients investigated with case history and a vast neurootological investigation. For comparison 25 consecutive neck trauma patients were introduced in the same test model. *Materials and Methods:* The case histories from the 25 patients were confirmed with neurootology including VNG with calorics and visual suppression, oculomotor tests and provoked dynamic posturography. The same questionnaire was used as in the first visit, the one year visit, and 12 years later. *Results:* The findings in the questionnaires include neck and back problems with pain and stiffness, oculomotor and vestibular abnormalities, pathological posturography. One astonishing finding in the late questionnaires was that vertigo, balance problems and symptoms from the entire back and limbs had not improved at all, but sooner had worsened over the 12 years. This is in accordance with another study in the literature. *Conclusions:* Whiplash symptoms may well get worse as years go by. Several neurophysiological explanations are at hand. Thus the patients have to be trusted. The opposite unfortunately often is the case.

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THERMAL THRESHOLDS IN TRIGEMINAL NERVE INNERVATED AREAS IN PATIENTS WITH CHRONIC WHIPLASH-ASSOCIATED DISORDERS

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Introduction: Several studies show a close anatomical and a functional relation between the jaw and neck regions. Earlier we have shown that head–neck movements are an intimate part of natural jaw activities, manifested as head extension in jaw opening and head flexion in jaw closing which indicates that impaired head movement could affect jaw function. This is corroborated by findings of disturbed jaw function in healthy subjects after experimental restriction of head–neck mobility, and in patients with restricted head–neck mobility due to neck injury. Also, patients with chronic WAD show impaired jaw/head movements and reduced endurance during chewing and report that jaw activities and eating are associated with pain and discomfort. In addition, an association has been shown between jaw and neck pain, and it has been suggested that trigeminal sensory impairment can follow whiplash injury. All these observations indicate an important sensori-motor integration between the jaw and neck. The aim of this study was to investigate whether such a relationship could be observed in patients with chronic WAD, by analysing the thermal thresholds in the trigeminally innervated facial skin with both a qualitative method and Quantitative sensory testing (QST). *Materials and Methods:* Seven women with chronic pain and dysfunction following a whiplash injury were compared to seven healthy age-matched women. Thermal detection thresholds were assessed with qualitative clinical testing and with QST according to the method-of-levels (Thermotest®, Somedic AB, Sweden). Seven test sites in the facial skin (bilaterally overlying each trigeminal branch, and also the midpoint of the chin) were examined. For the qualitative testing a cold (room tempered) and warm (45°C) metal spatula was used. At QST each location was tested with a series of 10 stimuli, starting from an adapted skin temperature of 32°C, with a warm/cold change in temperature of ±0.5°/s, and a return speed of 1°/s. The thresholds (cold and warm) for each location were defined as the means of the 10 individual thresholds in the sequence. *Results:* For the WAD patients, the qualitative examination demonstrated both reduced and increased sensitivity compared to healthy. QST however, showed significantly increased perception thresholds (i.e. reduced sensitivity) for both warm and cold stimuli. For the individuals who were assessed as having increased sensitivity in the qualitative examination, the QST displayed either normal or increased thresholds i.e. reduced sensitivity. The increased sensitivity found in the qualitative examination however, could reflect a tendency for thermal receptors to activate pain pathways or sensitization of nociceptors. *Conclusions:* These results suggest that QST is more sensitive for detecting thermal sensory disturbances in the face than a qualitative method. The lowered thermal sensitivity in the patient group might indicate a decrease in thermal detection capacity induced by pain.

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DIZZINESS AMONG PATIENTS WITH WHIPLASH-ASSOCIATED DISORDER – A RANDOMIZED CONTROLLED TRIAL

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Introduction: About 28% of the persons involved in road traffic collisions will develop whiplash, or whiplash-associated disorders (WAD). About 15–25% of these persons suffer from dizziness. Dysfunction in cervical mechanoreceptors and instability in the neck may cause dizziness among persons with WAD. Abnormal electronystagmo-grahpic findings have been reported and persons with WAD can exhibit disturbances in postural control. Current research has focused on vestibular rehabilitation for different causes of dizziness and shows evidence of cure and also relieve of symptoms. When treating dizziness among persons with WAD, the vestibular organ should be considered as well as postural control. Given this, it is of interest to examine whether dizziness related to WAD is possible to treat with vestibular rehabilitation. Therefore, the aim of this study was to investigate if vestibular rehabilitation may have an effect on clinical balance measures and self-perceived handicap among patients with dizziness associated with WAD. *Materials and Methods:* Twenty-nine patients with WAD and dizziness reported as a symptom participated in the study, 20 women and 9 men between 22 and 76 years of age. The study was a randomized, controlled trial where the patients were randomized to intervention group or control group. The intervention comprised vestibular rehabilitation. All patients were assessed at baseline, after sex weeks and after three months with four different balance measures and the Dizziness Handicap Inventory (DHI). Mann-Whitney *U* was used to test for differences between the groups and 95% confidence intervals were calculated for the median differences. The results were analyzed on an intention to treat basis, using last observation carried forward. An on treatment analysis was also performed for comparison. *Results:* After six weeks, the intervention group had statistically significant improvements compared to the control group in the following measures: standing one leg eyes open (SOLEO) ($p = 0.02$), blindfolded tandem stance ($p = 0.045$), DHI total score ($p = 0.047$), DHI functional score ($p = 0.005$) and in DHI physical score ($p = 0.033$). After three months, the intervention group had statistically significant improvements compared to the control group in the following measures: SOLEO ($p = 0.000$), tandem stance ($p = 0.033$) and DHI physical score ($p = 0.04$). *Conclusions:* Vestibular rehabilitation for patients with WAD can decrease self-perceived handicap and increase postural control. We find the result of our and other studies promising enough to encourage clinicians to consider vestibular rehabilitation as a possible treatment for patients with WAD and dizziness.

Reference

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AN ALTERNATIVE TECHNIQUE FOR LUMBAR MEDIAL BRANCH RADIOFREQUENCY: COMPARISON WITH THE EMPIRICAL TECHNIQUE

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Introduction: The zygapophyseal (facet) joint pain has been a challenging condition for pain specialists since the 20th century. According to the previous reports, degenerative changes of facet joint account for 10%–15% of the cases with chronic low back pain. However, it is a major source of frustration that there is no definitive standard to document a clinical diagnosis and few validated treatment about lumbar facet joint pain. Although it has been a subject of debate how best to select patients, radiofrequency (RF) neurotomy is frequently performed procedure for patients with lumbar facet generated pain. Lumbar medial branch radiofrequency (MBRF) is assumed to be effective and safe treatment for lumbar facet joint pain with 1.0% rate of minor complications per lesion site. The rationale and efficacy of lumbar MBRF would depend on the use of meticulous radiofrequency (RF) needle placement with stringent patient selection. In spite that variable techniques for lumbar MBRF exists, the tunnel vision technique is widely recommended for exact RF needle placement. However, this method uses the concept of a steep caudocephalad axial tilt of the fluoroscopy beam, which result in unusual appearance of vertebral structures and a long distance from skin to the target site. In our institution, therefore, we have used a modified method that is easy and safe to place RF needle parallel to the lumbar medial branch in oblique fluoroscopic view. Accordingly, our objectives were to evaluate our modified technique for lumbar MBRF, comparing with the tunnel vision technique, and additionally to assess complications with respect to these two techniques. *Materials and Methods:* In this prospective comparative study, 30 patients underwent our alternative technique vs. 30, who underwent the tunnel vision technique. The effectiveness was evaluated using 11-point numeric rating scale and Oswestry disability index. Five point satisfaction scales at 1-month follow-up was used to evaluate the response to the procedure. Post-radiofrequency complication was compared between the two technique groups. *Results:* In the study, no significant differences were observed between the alternative and the tunnel vision technique groups in terms of NRS and ODI scores. However, neuritic pain associated with RF procedure was significantly more prevalent in the tunnel vision technique group (3.2%) than in the alternative technique group (0%). According to the 5-point satisfaction scale, 51 patients (82%) responded successfully to the procedure at one-month follow-up visit. *Conclusions:* In conclusion, this clinical trial supports the view that lumbar MBRF in selected patients with chronic lumbar facet joint pain provides effective pain relief and functional improvement at 1-month post-procedurally. Furthermore, no significant differences were observed between the alternative technique and the tunnel vision technique with respect to NRS and ODI scores. If performed correctly, lumbar MBRF should be largely free of complications, but our findings show that the L1–3 medial branch ablation using the tunnel vision technique, is more likely to cause lateral branch neuritis. This result highlights the need to ensure correct RF needle placements.

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EARLY MULTIMODAL INTERVENTION IN PATIENTS WITH ACUTE WHIPLASH-ASSOCIATED DISORDERS (WAD)

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Introduction: The aim of the present study was to assess the effects of an early multimodal cognitive, behaviour based WAD rehabilitation program. *Materials and Methods:* 52 patients (17 men and 35 women) were consecutively enrolled during August 2008–August 2010 commonly after a referral by General Practitioners. In average 3 months had passed since the accidents. All patients underwent physical examination and functional assessments by a multidisciplinary team. Self reported questionnaires were used; Short Form SF-36, EuroQol dimensions (VAS and index) and Hospital Anxiety and Depression scale (HAD). Patients were assessed before entering the program, after and at six-month follow-up. *Results:* Bodily Pain (BP) was rated as mean 25 before, as 35 at the end and as 37 at the follow-up. The reduction was significant ($p < 0.000$) at the end and at the follow-up. Physical functioning (PF) and Role Physical (RP) were significantly improved ($p < 0.05$) at the follow-up. Mood, 26 patients experienced anxiety and 18 depressions before the program. Depression was significantly reduced ($p = 0.008$) at the end as the follow-up ($p = 0.012$). Anxiety was significantly reduced at the end ($p = 0.001$). Quality of life state, EQ-5D VAS was rated as mean 44 before, as 51 at the end and as 53 at the follow-up. The improvement was significant ($p < 0.006$) after the program which sustained at the follow-up. The EQ-5D index was rated as mean 0.357 before, as 0.474 after and as 0.476 at the follow-up. The improvement was significant ($p < 0.009$) after the program which sustained at the follow-up. *Conclusions:* Our study suggests that an early multimodal rehabilitation program results in pain alleviation, improvement in mood and better quality of life. However, the findings must be interpreted with care as part of the effects may be attributed to normal healing.

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BOTULINUM TOXIN A IN ACUTE WHIPLASH INJURY. A PROSPECTIVE RCT STUDY. PRELIMINARY FINDINGS

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Background: To day no known effective treatment is available for acute WAD. In chronic whiplash patients we have found dystonic features by EMG in more than 100 cases (Kasch et al. In prep). If patients present with dystonic neck muscles BTX-A is a possible treatment option and in open studies more than 40% have more than 50% headache/neckpain pain relief. *Methods:* 44 acute high risk whiplash patients exposed to MVA with no contact trauma, no loss of consciousness and no previous significant pain or other illness are consecutively included after verbal and written consent. Patients are randomized to either BTX-A or isotonic saline given EMG guided into neck muscles if dystonic activity is found (> 250 turns/s). A group of 12 age and gender matched controls of low risk patients are also seen and examined with EMG. Treatment and examination takes place between 2 and 4 weeks after injury. *Results:* Preliminary findings of marked dystonic features in previous healthy patients will be presented. *Conclusion:* Dystonic muscle activity in deep neck muscles such as splenius capitis and splenius cervicis, semispinalis and the multifidus and scalene muscles is identified in high risk acute WAD and might be targeted by BTX-A.

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COGNITIVE SYMPTOMS, CERVICAL RANGE OF MOTION AND PAIN AS PROGNOSTIC FACTORS AFTER WHIPLASH TRAUMA

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Objectives: To evaluate pain, cervical range of motion (CROM) and cognitive symptoms as predictors for poor prognosis defined as sick leave 3 years later. *Material and methods:* In 97 patients CROM, pain intensity and cognitive symptoms were measured immediately following trauma, at 6 months and 3 years. Patients were also asked at 3 years if they had been on sick leave the last 6 months. *Results:* Pain intensity and reduced CROM were not clinically useful as predictors of later sick leave. The best predictors were presence within 96 h after injury of the two cognitive symptoms 'being easily distracted' (odds ratio 8.7–50) and 'easily irritated' (odds ratio 5.3–31). *Conclusions:* Initial pain and reduced CROM may be related to minor tissue damage which often heals while late functionality is more dependent on other factors such as cognitive dysfunction. For patients with whiplash associated disorders two simple questions should be asked; 'Are you currently easily irritated?' and 'Are you currently easily distracted (e.g. is it difficult for you to follow a conversation if several people are talking in the room at the same time)?'. An affirmative answer to any of these questions indicates an increased risk for poor prognosis defined as sick leave 3 years later.

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