Whiplash injuries: Clinical picture and diagnostic work-up

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This paper was supported by a grant from the Ministry of Public Health (ICS 57.2/RF 93.28, ISPEL 93-95).

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Clin Exp Rheumatol 2000: 18 (Suppl. 19): S23-S28.

Key words: Whiplash, cervicogenic headache, cervical spine kinematic analysis.

ABSTRACT

The term "whiplash" commonly refers to symptoms and signs associated with a mechanical event such as a sudden acceleration and deceleration of the neck (due, in the majority of cases, to a road accident), instead of to the mechanism itself. The recent Quebec Classification of Whiplash Associated Disorders (WAD) contributed to define nosographically all the clinical manifestations usually grouped under the terms acute/post-traumatic and late "syndrome". In the late phase of WAD, neck pain and neck muscle contraction have been reported in all cases, together with headache in over 50%. "Headache stemming from the neck", despite numerous attempts to classify this entity (i.e. cervicogenic headache) according to the IASP classification (headache associated with neck disorders), is still a subject of debate. An adequate multiparametric procedure is required to study WAD, which takes into account: the patient's principal details; an exact reconstruction of the event; description and analysis of the signs and symptoms, with various complications and correlated dysfunctions; an objective neurological and neck-shoulder examination; and a battery of complementary instrumental tests which are described in this study. These investigations include evaluation of muscle tension (manual palpation, algometry, EMG recording), kinematic analysis of the cervical spine, neuropsycological and psycological evaluation, and evaluation of disability. In order to assess cervical spine mobility in WAD patients, a 3D kinematic analysis by means of the ELITE system and clinical evaluation were performed in our setting. Seventy patients with whiplash injury and 46 healthy volunteers were enrolled in the study. Patients were tested at the time of first consultation and again 6 months and 12 months later. Clinical evaluation of the range of motion was performed both in patients and in 41 healthy volunteers. Furthermore, patients diagnosed according to the WAD Classification as grade 2 (n = 68) or grade 3 (16) underwent a Quality of life (QoL) evaluation, measured using the short form (36-item) Health Survey (SF36) and the migraine-specific questionnaire (MSQ). According to our data, whiplash patients showed an impairment of cervical spine mobility, as well as a poor QoL, compared to a control group population, even though we observed a trend towards improvement over time in cervical ROM.

Introduction

Generally speaking, the term "whiplash", introduced by Crowe in 1928, refers exclusively to the mechanism - hyperextension and subsequent flexion of the head - by which an injury to the neck (and damage to the structures of the neck) is sustained as a result of a sudden acceleration or deceleration due, in the majority of cases, to the impact of a road accident. In common usage, however, this term refers instead to the whole group of symptoms associated with a mechanical event such as the one just described and it is from this looser usage that terms such as acute/post-acute and late "syndrome" (or chronic sequelae), often used in practice, derive. Even the more recently introduced term Whiplash-Associated Disorders or WAD (1) must, since it constitutes neither a new syndrome nor a diagnostic category, be regarded as a general heading under which a number of clinical manifestations, different in terms of their magnitude, severity and duration, can (due to their clear cause-effect relationship with a whiplash injury) be grouped and then classified (singly or in subgroups). The above-mentioned clinical manifestations include symptoms and signs that relate to the neck (spine/ ligaments/ discs/ muscles/ medulla/ nerve roots) as well as somatic "extracervical", neurosensory, behavioural, cognitive and affective disorders whose appearance and mode of expression/evolution can vary widely over time in various cases (2-5).

As in cases of head injury and related disorders, whiplash injury is followed, in the acute phase and during the first few weeks, by the development of a number of quite commonly observed symptoms. In the majority of cases (i.e., in so-called uncomplicated whiplash cases) these symptoms will be related to what we describe as "simple" cervical distortion (and not, therefore, to traumatic disc protrusions, direct or indirect spinal or radicular injury, fractures or vertebral dislocations or to other complications that are not embraced by the definition of uncomplicated whiplash).
In addition to the strictly cervical, cervicocephalic and cervicomedullary symptoms mentioned above, it is also necessary to consider other "extracervical" syndromes (as well as other diagnoses!) (6) associated with whiplash injury which, unlike these symptoms, do not depend particularly on the severity of the trauma itself: occipital neuralgia, painful temporomandibular dysfunction, tight chest syndrome, shoulder disorders at the articular and periarticular level, the so-called upper quadrant syndromes and low back pain, fibromyalgia and, rarely, reflex sympathetic dystrophy.
In general, however, the somatic and psychic disorders which emerge in the short and medium term following a whiplash injury are easily linked to dysfunction mechanisms and "simple" damage which can, if necessary, be reproduced and investigated in animal models, and which do not generate uncertainty over the causal relationship between the traumatic event and the clinical phenomena, even though it is still not possible using current diagnostic tools to demonstrate the possible microlesions of the organs and tissues involved in their genesis (1-7).
Later, however, in the context of persistent and chronic sequelae, it is not rare to see the isolation of certain symptoms or groups of symptoms which, becoming more complex and recognisable as part of a syndrome picture, present a chronic continuous or remitting/relapsing pattern whose onset is often preceded by a symptom-free, or apparently free interval (a silent, or subclinical phase) which may mask, and render uncertain, the causal link with the traumatic event.

Whiplash-associated disorders: Clinical-pathogenetic correlations

The monograph of the Quebec Task Force on Whiplash-Associated Disorders (1), published in 1995, helped to redefine, on the basis of a broad population study and a series of consensus conferences, the guidelines for and the elements essential in the diagnostic and therapeutic assessment of this condition. For the preliminary definition of WAD, 5 categories were established on the basis of the severity of the damage and the clinical-anamnestic and objective features of the case presentation. Only 3 of the 5 grades refer to uncomplicated damage to the soft tissues, and these are the categories pertinent to this review.
Grade 1 cases present isolated symptoms of neck involvement, with pain and stiffness (but no muscular contracture) attributable to microscopic soft tissue lesions, short-lasting phlogistic oedema and rapid functional recovery (days). Grade 2 and 3 cases show, respectively, muscular-skeletal signs and symptoms, reduced Range of Motion (ROM), tender points and neurological signs (hyposthenia, sensory deficit, osteotendinous hypoareflexia). Muscle spasm and contracture secondary to muscle-ligament damage (strain with oedema and minor haemorrhages) and to possible joint capsule laceration are always present, however, as well as possible further damage to nervous structures which may be direct (mechanical) or indirect (secondary to soft tissue damage). Other symptoms such as headache, hypacusia, tinnitus, dizziness, dysphagia, temporomandibular pain and memory disorders may be associated with any one of the different grades of dysfunction.
Significant prognostic correlations have emerged from a number of studies (8, 9) which have considered, as predictors of the long-term outcome, variables relating to the dynamics of the accident and to the initial symptoms: unexpected impact sustained under stationary conditions and with the head turned and bent; high symptom severity scores at the first observation; higher incidence of headache in the initial phases; and the association of severe headache and neck pain in the acute phase. Other factors thought to be correlated with delayed recovery or with the evolution into a chronic picture are female sex, age, a history of traumas and degenerative spinal pathologies, and conditions of anxiety, irritability, depression and insomnia existing prior to the injury or emerging during the acute and post-acute phases (10-14).

Symptoms of the chronic phase and their classification

Neck pain and neck muscle contracture have been reported in all cases of late-phase WAD, together with headache in over 50% (8, 9).
A number of attempts have been made to classify the entity known as "headache stemming from the neck", and in the literature various methodological approaches have been tried, each of which, after apparently being confirmed, has fallen into disuse. Examples of this are Barré's posterior cervical sympathetic syndrome (15) and Bärtschi-Rochaix's (16) cervical migraine. In the course of the last ten years, Sjaastad (17) has taken up and further developed the concept of "headache stemming from the neck", identifying and clinically characterising the syndrome known as cervicogenic headache. Currently, in accordance with the International Association for the Study of Pain (IASP) classification (18), occipital neuralgia, sub-occipital muscular-skeletal pathologies and neck, shoulder and arm pain of neurological origin all appear in the category of headache associated with neck disorders. The IASP recognises pathologies such as distortional injuries (e.g. whiplash) and degenerative conditions such as cervical spondylosis as being responsible for headache.
In the International Headache Sociaty (IHS) classification (19), headache associated with neck disorders is restricted to disorders of the cervical spine and cases of retropharyngeal tendinitis (more rarely encountered), while occipital neuralgia is more correctly grouped with the cranial neuralgias. It can be seen from closer analysis of this classification and especially of the criteria for headache associated with neck disorders, that there are clear differences between the diagnostic criteria for this type of headache and those for occipital neuralgia. Furthermore, even though it is not to be ex-

cluded altogether, no particular importance is attached to the criterion of unilaterality. The radiological criteria given also appear in some ways restrictive as they take into account only the possibility of highlighting an alteration of the cervical spine during flexion-extension movements, and thus fail to consider that severe limitations in rotation and or lateral bending of the neck are often detected in clinical practice.

Special mention should be made of the symptomatological picture of the so-called whiplash syndromes that have been incorporated into the IASP classification (such as Vijan and Dreyfus's post-traumatic dysautonomic cephalalgia (20) and Sjaastad's cervicogenic headache which we mentioned earlier). According to Sjaastad, cervicogenic headache is an independent nosographic syndrome, distinct from other pain syndromes (19, 21). Since it can be due to the involvement of a number of structures in the neck (nerves, ganglia, zigapophyseal joints, discs, bone, periosteum, muscles, ligaments, etc.) it should perhaps be defined in terms of a "syndrome" rather than strictly as an "illness". Cervicogenic headache is defined as a unilateral pain without side-shift which stems from the neck and spreads to the oculofrontotemporal region and is accompanied by the presence of signs and symptoms of neck involvement (21). The pain is usually of moderate intensity, and can be either episodic (with attacks of varying length) or continuous (fluctuating over time with exacerbations lasting from a few hours to a number of days). It may be accompanied by neurovegetative signs and symptoms (photo-/phonophobia, nausea, vomiting, etc.). There is also an antalgic reduction in cervical spine movement. Other characteristic features of this headache include its preponderance in female subjects and the presence of a cranial/cervical injury (markedly, whiplash) in the patient's history.

Given that a unilaterality of pain constitutes the main feature of cervicogenic headache, the differential diagnosis of this condition involves, essentially, those headaches in which the pain is unilateral (22). Other features peculiar to cervicogenic headache are the presence of mechanisms capable of triggering an attack that resembles a spontaneous attack, and the absence, upon radiographic investigation, of morphological alterations of the cervical spine.

Within the ambit of whiplash-related headaches, other diagnoses (which refer to the main headache groups are also possible using the IHS system (19, 23): primary headache, migraine, tension headache, cluster headache, mandibular dysfunction, etc.).

Apart from the symptoms of anxiety, irritability and insomnia found in 48-78% of the population studied by Pearce (9), no other symptom or group of symptoms (including dizziness, postural and gait disorders) occurs in the late phases of the WAD syndrome at a frequency of over 30%.

Diagnostic work-up and evaluation

If further progress is to be made in the definition and study of WAD, a systematic approach to the evaluation of individual patients is essential. For such an approach to be possible, we first need a multiparametric procedure (1) which takes into account:

(i) the patient's principal personal details (previous and/or concomitant pathologies and traumatisms, surgical operations and other congenital or acquired conditions that might alter his/her state of health, homeostasis and capacity to adapt to the consequences (somatic or psychological) of the traumatic event;
(ii) an exact reconstruction of the event which caused the injury and its context;
(iii) a description and analysis of the core symptoms, associated signs and symptoms, various complications (local and distant), and the full spectrum of correlated dysfunctions (and disabilities);
(iv) an objective neurological and physiatric examination and the full battery of complementary tests described below.

Evaluation of muscle tension

There are a number of diagnostic methods that can be used to evaluate muscle tension. The IHS recommends manual palpation or pressure algometry or, alternatively, EMG recording at rest and during muscle activation (24, 25).

Manual palpation is a clinical method for evaluating the tension and tenderness of the pericranial musculature. The areas examined are standardised and correspond to possible trigger zones at the level of the tendinous insertions and scalp musculature (frontalis, masseter, trapezius muscles, etc.). Constant pressure (2-3 kg/cm^2) is exerted on the structures being examined, and the patient's reaction is evaluated on a scale of 0-3: 0 = no pain; 1 = the patient says he feels pain but shows no apparent reaction; 2 = the patient says he feels pain and shows a clear reaction; 3 = the patient complains of intense pain and shows a marked reaction. This method clearly has limitations: above all, the subjectivity of the evaluation of the responses and possible inter-examiner variability (26).

Algometry is a method for measuring the pain threshold of the cephalic and extracephalic osteomyelotendinous structures in response to the application of pressure using a manual (kg/cm^2) or electronic instrument (26). In the electronic version a gradually increasing force (speed approximately 100 g/s) is applied to the point being tested. A pressure algometer supplies quantitative data which shows good reproducibility between sessions. The test is carried out on standardised cranial and extracranial reference points. The patient is instructed to press a button when the pressure sensation becomes painful. The pressure pain threshold is thus displayed. Measurements are carried out on the left and right sides alternately and are repeated at least twice for all reference points. The method showed good reproducibility in a control population (25-28).

The advantage of EMG recording over clinical evaluation is that it provides an objective and precise quantification of the degree of muscle tension. These studies (miomonitor) are carried out using surface electrodes under resting conditions and during muscle activation exercises. Pericranial muscles can be activated by maximal contraction and by cognitive or psychological stress (mental arithmetic, exposure to stressful images etc.). During the recording of muscle activity, other psychophysiological

parameters such as skin conductance, heart rate and respiratory frequency can also be recorded (25).

Kinematic analysis of the cervical spine

This method requires the application of techniques (such as three-dimensional radiography, goniometry and electrogoniometry) whose evaluation, compared to the clinical approach, is often quite complex and difficult. Recently, however, new methods have been introduced for the 3D real-time monitoring and computer analysis of motion which can provide interesting results with regard to the movement of different sections of the neck. One of these, the ELITE kinematic motion analysis system (version 5.4 BTS, Milan) (29) currently in use in our laboratory, allows the evaluation of the linear and angular velocity, the acceleration and the range of motion of individual markers placed on different segments of the cervical spine. The method is reproducible, easy to use, and requires no particular effort on the part of the patient, who merely has to repeat a series of head movements (flexion, rotation, inclination and extension) in different sequences (29).

During the course of our study of tension headaches and of selected series of WAD patients, we have obtained important information on the validity, sensitivity and specificity of the above methods, applied both singly and in combination with one another.

Kinematic analysis in whiplash

The results from a case series of post-whiplash patients who underwent a standard diagnostic work-up are briefly described, with reference to the 3D kinematic analysis.

Seventy patients (M/F 18/52; mean age 28 ± 6.17 yrs.) with uncomplicated whiplash injury and 46 healthy volunteers (M/F 25/21, mean age 32.7 ± 9.14 yrs.) were enrolled in the study. The illness duration was < 1 year in 42 patients (in 26 it was < 6 months) and > 1 year in 28. In accordance with the Quebec Task Force Classification of Whiplash-Associated Disorders (1995) (1), 56 were diagnosed as grade 2 and 14 as grade 3. All of them suffered from unilateral headache and/or neck pain.

Thirty patients were tested at the time of first consultation (T0) and again 6 months later (T6). Twelve of these were also evaluated 12 months after their first consultation.

The ELITE system, which uses 2 infrared TV cameras and works at a sampling rate of 50Hz, provides 3D coordinates of visible passive markers, allowing the range of motion (ROM) of the cervical spine with respect to the trunk (in degrees) to be established. The reliability of this method has been confirmed in a previous study (29).

Clinical evaluation of ROM was performed both in patients and in 41 healthy volunteers (M/F 13/28; mean age 57 ± 17.9 yrs.). ROM was classified as follows: 1 = dysfunction rated as 75%; 2 = dysfunction rated as 50%; 3 = dysfunction rated as 25%; 4 = no dysfunction.

The patients were also evaluated using a structured interview and screened by mean of a questionnaire which applies the diagnostic criteria for cervicogenic headache (CEH) (21), migraine without aura (M) (IHS), and headache associated with neck disorders (HN) (IHS) and divided into the following diagnostic groups: CEH 34.3%, M 11.4%, HN 14.3%, CEH+M 11.4%, CEH+HN 8.6%, and no diagnosis 20% (30).

No significant differences emerged between CEH patients and those in the other headache groups. At the 6-month follow-up (T6), a trend towards improvement of the ROM emerged among whiplash patients, with rotation to the left showing a significant amelioration ($p < 0.05$, Student's paired t-test) in comparison with the results of the first consultation (T0). At the 12-month follow-up (T12), meanwhile, no significant differences emerged from a comparison with the values of the first (T0) and second (T6) consultations, even though cervical spine mobility showed a trend towards improvement. According to our data, whiplash patients showed an impairment of cervical spine movement, even though we observed a trend towards improvement over time.

Neuropsychological and psychological evaluation

Evaluation of cognitive functions in patients with WAD may prove necessary when there is persistent impairment of attention and memory and when subjects experience difficulty in returning to their normal activities (especially those of an intellectual and more complex nature). The tests of cognitive impairment are, generally speaking, borrowed from the batteries developed for the investigation of neurocognitive disorders following mild head injury (31) such as: the Paced Auditory Serial Addition Task (PASAT); simple and multiple choice reaction times; Stroop's colour interference test; the Trail Making Test (Parts A and B); the Brown-Peterson Auditory Short-Term Memory Task; and forced choice testing (5).

From a behavioural point of view, as well, certain symptoms also seen in post-concussive syndrome following mild (direct) head injury (32-35) might suggest organic (frontal) impairment (executive functions and control). These patients can also develop affective-behavioural disorders (emotional instability, aggressiveness, reduced tolerance to frustration) which, together with the above-mentioned cognitive disorders, make it difficult for the subject to control his mental activity. These affective-behavioural dysfunctions can be investigated using a wide variety of tests which allow the separate and more in-depth analysis of different groups of symptoms and aspects relating to the subject's motivation, coping style and, in more general terms, personality characteristics (projective tests and questionnaires): the State-Trait Anxiety Inventory (STAI-Y 1/2) for the evaluation of the state and traits of the patient's anxiety; the Rome Depression Inventory; the Paykel Scale (stressful events); and the Minnesota Multiphasic Personality Inventory (MMPI) (36-38).

Evaluation of disability

Given that most late-phase WAD symptoms can be superimposed, partially or totally, on those of the various headaches, particularly migraine, the widely validated instruments used for the study of headaches and other chronic and disabling conditions (depression, arthritis, diabetes) can thus also be considered suitable for evaluating the quality of life

of patients with this syndrome.
Instruments such as the SF20 and SF36 are designed to evaluate not only pain and physical functioning, but also mental health, a subject's functioning in social situations and at work and, eventual role limitation (39).
More specific aspects such as pain and functional limitation can be assessed using different indices of chronic pain (such as Van Korff's Chronic Pain Index) whose validity has been amply demonstrated in chronic (somatic) pain syndromes (40).
When headache is a predominant symptom, ad hoc instruments can be used such as the Headache Impact Questionnaire (HimQ) (41) and the Migraine Disability Assessment Questionnaire (MIDAS) (42). A pilot study is currently underway in order to validate the latter in Italy.

Quality of life
Eighty-four patients (M/F 18/66, mean age 33.0 ± 8.9 yrs.) diagnosed according to the Quebec Task Force Classification (1995) as grade 2 (n = 68) or grade 3 (n = 16) underwent a Quality of life (QoL) evaluation using the Short-form 36-item Health Survey (SF36) and the migraine-specific quality of life questionnaire (MSQ). SF36 is made up of 8 health scales [Physical functioning (PF), Role limitation due to Physical problems (RP), Bodily Pain (BP), General Health perception (GH), Vitality (V), Social functioning (SF), Role limitation due to Emotional problems (RE), and general Mental Health (MH)] which together assess 3 health-related areas: 1) functional status; 2) well-being and 3) perception. The MSQ consists of 16 items analyzing 3 categories of effects: Role Restrictive (RR), Role Preventive (RP), and Role Emotional (RE). The questionnaire requires patients to record the effects of migraine attacks on various aspects of their QoL over a period of 4 weeks prior to the evaluation.
In whiplash patients QoL was found to be significantly ($p < 0.001$) impaired in all areas (with the exception of General Health) compared to a control group population. Females and males were significantly more impaired in all items (except general health) than their sex-matched controls.
When comparing patients with an illness duration < 1 year and those with a longer illness duration, Vitality emerged as significantly ($p < 0.05$) improved in the latter. On the MSQ questionnaire, Role Restrictive and Role Emotional emerged as categories showing significantly less impairment ($p < 0.05$) in patients with a longer illness duration than in those with a recent whiplash headache.
A poor quality of life was thus observed in whiplash patients, when compared to a control group population. Both the MSQ and the SF36 questionnaires showed social activity and emotional functioning to be the areas most impaired in patients with a recent neck trauma. This was due to the presence of an "acute" whiplash syndrome in these subjects.

Acknowledgments
We wish to thank Prof. Ottar Sjaastad for his collaboration in developing the diagnostic criteria questionnaire and reviewing the manuscript and Dr A. M. Grande for recruiting the patients for this study.

References
1. CASSIDY JD (Ed.) and the Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders: Redefining "whiplash" and its management. *Spine* 1995; 20: 8S.
2. ETTLIN TM, KISCHKA U, REICHMANN S *et al.*: Cerebral symptoms after whiplash of the neck: A prospective clinical and neuropsychological study of whiplash injury. *J Neurol Neurosurg Psychiatry* 1992; 55: 943-8.
3. BENTON AL: Behavioral consequences of closed head injury. *In*: ODOM GL (Ed.): *Central Nervous System Trauma Research Report.* Bethesda, MD, NINCDS National Institute of Health, 1979; 220-3.
4. KISCHKA U, ETTLIN TM, HEIM S, SCHMID G: Cerebral symptoms following whiplash injury. *Eur Neurol* 1991; 31: 136-40.
5. American Academy of Neurology: Annual Courses. New York 1993, vol. 5, Head Injury, pp 221-(1-62).
6. MAGNUSSON T: Extracervical symptoms after whiplash trauma. *Cephalalgia* 1994; 14: 223-7.
7. BOGDUK N: The anatomy and pathophysiology of whiplash. *Clin Biomech* 1986; 1: 92-101.
8. BALLA JL: The late whiplash syndrome. *Aust NZ J Surg* 1980; 50: 610-4.
9. PEARCE JM: Whiplash injury: A reappraisal. *J Neurol Neurosurg Psychiatry* 1989; 52: 1329-331.
10. MILLER H: Accident neurosis. *Br Med J* 1961; 1: 919-25, 992-8.
11. KELLY R, SMITH BN: Post-traumatic syndrome: Another myth discredited. *J R Soc Med* 1981; 74: 275-7.
12. MERSKEY H: Psychiatry and the cervical sprain syndrome. *Can Med Assoc J* 1984; 130: 1119-21.
13. American Psychiatric Association, Committee on Nomenclature and Statistics: *Diagnostic and Statistic Manual of Mental Disorders Revised.* Italian ed. Masson 1988.
14. BINI L, BAZZI T: *Trattato di Psichiatria*. 2° edizione, Vallardi Milano, 1972.
15. BARRÉ M: Sur un syndrome sympatique cervical posterieur et sa cause fréquente: líarthrite cervical. *Rev Neurol* (Paris) 1926; 33: 1246-8.
16. BÄRTSCHI-ROCHAIX W: Migraine cervicale, das encephale Syndrome nach Halswirbeltrauma. Berne, Huber 1949.
17. SJAASTAD O, DAUNTE C, HOVDAL H, BREIVIK H, GRONBACK E: "Cervicogenic" headache. An hypothesis. *Cephalalgia* 1983; 3: 249-56.
18. International Association for the Study of Pain. Subcommittee on Taxonomy: Classification of chronic pain. *Pain* 1986; 3: 1-225.
19. Headache Classification Committee of the International Headache Society: Classification and diagnostic criteria for headache disorders, cranial neuralgias and facial pain. *Cephalalgia* 1988; 8 (Suppl. 7): 1-96.
20. VIJAYAN N, DREYFUS PM: Post-traumatic dysautonomic cephalagia, clinical observations and treatment. *Arch Neurol* 1975; 31: 649-53.
21. SJAASTAD O, FREDRIKSEN TA, PFAFFENRATH V: Cervicogenic headache diagnostic criteria. *Headache* 1990; 30: 725-6.
22. ANTONACI F: *Chronic Paroxysmal Hemicrania and Hemicrania Continua: Two Different Entities ?* NTNU Trondheim, Norwegian University of Science and Technology, Tapir Publ., Trondheim, 1998.
23. HAAS DC: Chronic post-traumatic headaches classified and compared with natural headaches. *Cephalalgia* 1996; 16: 486-93.
24. JENSEN R, RASMUSSEN BK, PEDERSEN B, LOUS I, OLESEN J: Cephalic muscle tenderness and pressure pain threshold in a general population. *Pain* 1992; 48: 197-203.
25. SANDRINI G, ANTONACI F, MICIELI G, MARTIGNONI E, BONO G, NAPPI G: Methodologies for evaluating the pain control system in primary headaches. *In* DE MARINIS M and GRANELLA F (Eds.) *Ten Years of Headache Research in Italy - In Memoriam of Alessandro Agnoli.* Rome, CIC Ed. Internat. 1995, pp 19-32.
26. SANDRINI G, ANTONACI F, PUCCI E, BONO G, NAPPI G: Comparative study with EMG, pressure algometry and manual palpation in tension type headache and migraine. *Cephalalgia* 1994; 14: 451-7.
27. ANTONACI F, BOVIM G, FASANO ML, BONAMICO L, SHEN J-M: Pain threshold in humans. A study with the pressure algometer. *Funct Neurol* 1992; 7: 283-8
28. ANTONACI F, SAND T, LUCAS GA: Pressure algometry in healthy subjects: Inter-examiner variability. *Scand J Rehabil Med* 1998; 30: 3-8.
29. BULGHERONI MV, ANTONACI F, GHIRMAI S, SANDRINI G, NAPPI G, PEDOTTI A: A 3D kinematic method for evaluating voluntary movements of the cervical spine in humans. *Funct*

Neurol 1998; 3: 239-45.

30. ANTONACI F, GHIRMAI S, BONO G, SANDRINI G, NAPPI G: Headache originating/starting from the neck: Evaluation of diagnostic criteria. Submitted
31. AUERBACH SH: Neuroanatomical correlates of attention and memory disorders in traumatic brain injury: An application of neurobehavioral subtypes. *J Head Tr Rehabil* 1986; 3: 1-12.
32. LEVIN HS, BENTON AL, GROSSMAN RG: *Neurobehavioral Consequences of Closed Head Injury*. NY, Oxford University Press, 1982.
33. LEZAK M: *Neuropsychological Assessment*. NY, Oxford University Press, 1983.
34. ADAMS JH, GRAHAM DI, GENNARELLI TA: Neuropathology of acceleration-induced head injury in the subhuman primate. *In* GROSSMAN RG, GILDENBERG PL (Eds.): *Head Injury: Basic and Clinical Aspects*. New York, Raven Press 1982: pp 141-50.
35. BINDER LM: Persisting symptoms after mild head injury: A review of the post-concussive syndrome. *J Clin Exp Neuropsychol* 1986; 8: 323-46.
36. SPIELBERGER CD,GORSUD RL, LUSCHENE R, VAGG PR, JACOBS GA: *Manual for the State-Trait Anxiety Inventory*. Palo Alto, CA. Consulting Psychologist Press, 1983, p. 36.
37. PAYKEL ES, PRUSOFF BA, UHLENHUTH EH: Scaling of life events. *Arch Gentile Psychiat* 1971; 25: 340-7.
38. HATHAWAY SR, MCKINLEY JC: *The Minnesota Multiphasic Personality Inventory Manual* (revised). New York Psychological Corporation 1951.
39. TALOW AR, WARE JE, GREENFIELD S, *et al*.: An application of methods for monitoring the results of medical care. *JAMA* 1989; 262: 925-30.
40. VAN KORFF MR, ORMEL FJ, *et al.*: Grading the severity of chronic pain. *Pain* 1992; 50: 133-49.
41. STEWART WF, PIPTON RB, SIMON D, VAN KORFF MR, LIBERMANN J: Reliability of illness severity measures for headache in a population sample of migraine sufferers. *Cephalalgia* 1998, 18: 44-51.
42. BUSSONE G, D'AMICO D, FERRARIS A, LEONE M, GRAZZI L: Disabilità nel paziente emicranico. *In* PUCA F *et al.* (Eds.): Le Cefalee - Atti Corso Aggiornamento Nazionale SISC, Caserta, 6/9/dic, 1998. TETI, Napoli, 1998, pp 83-91.