CME

Handicap after acute whiplash injury

A 1-year prospective study of risk factors

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Article abstract—*Background:* Exposure to a whiplash injury implies a risk for development of chronic disability and handicap, with reported frequencies ranging from 0% to 50% in follow-up studies. The exact risk for development of chronic whiplash syndrome is not known. *Objective:* To prospectively determine the sensitivity and specificity of five possible predictors for handicap following a whiplash injury. *Methods:* In a 1-year prospective study of persons with acute whiplash injury (n = 141) and control subjects who had acute ankle distortion (n = 40), pain intensity, number of nonpainful neurologic complaints, cervical mobility, workload during extension and flexion of the neck, and results of psychometric assessment were recorded. The consecutively sampled injured persons were assessed with structured and semistructured questionnaires, and underwent neurologic examination after 1 week and 1, 3, 6, and 12 months. After 3 to 4 years, participants with whiplash injury were questioned about legal issues. *Results:* After 1 year, 11 (7.8%) persons with whiplash injury had not returned to usual level of activity or work. The best single estimator of handicap was the cervical range-of-motion test, which had a sensitivity of 73% and a specificity of 91% ($p < 0.01$, Cox regression analysis). Accuracy and specificity increased to 94% and 99% when combined with pain intensity and other complaints. This increase was gained at the expense of a reduced sensitivity. Initiation of lawsuit within first month after injury did not influence recovery. *Conclusion:* The cervical range-of-motion test has a high sensitivity in prediction of handicap after acute whiplash injury. The value of cervical range-of-motion test is further improved by additional recording of symptoms and pain intensity.

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In whiplash injury, acceleration and deceleration forces acting on the neck during collision cause strain and sprain of soft tissues in the neck, and some patients develop long-term sequelae, known as *late whiplash syndrome*.[1,2] The proportion of persons developing chronic disability after acute whiplash injury varies considerably, with figures ranging from 0%[3] to 50%,[4] and even rising to 75% in a cohort with 15-year follow-up.[5] This variation is not solely explained by factors such as differences in traffic density, car safety, or leisure activity levels,[6-8] and it has been proposed that biopsychosocial factors[3,9] and the type of insurance system may play important roles in the long-term outcome.[10,11]

In prospective studies, neck pain, neck stiffness, headache, and shoulder pain are frequently reported symptoms. Other less common symptoms are arm pain; numbness in the shoulder, arm, or hand; dysphagia; dizziness; and visual and auditory disturbances.[12-15] Symptoms persist in some injured persons, requiring long-term sick leave and disability pensions and giving rise to legal claims. The mechanisms underlying late whiplash syndrome are not known. Despite intensive research, it has not been possible to demonstrate specific, pathologic changes that can explain late whiplash syndrome.[16] Lack of clear neurologic abnormalities together with normal findings in imaging studies have raised the possibility that whiplash syndrome is a stress-related disorder caused by the injury.[17-19] Although some studies suggest that psychological factors play a role in short-term recovery,[13] others did not find initial psychological factors to be crucial for long-term handicap.[20]

Although the pathophysiology remains unclear, it is important to identify risk factors for whiplash. In a carefully conducted Swiss study,[21,22] it was found that persistence of symptoms after 1 year and 2 years could be related to a previous head injury, severe initial headache, or to severe neck pain intensity. Restricted neck movement was suggested to predict outcome at 1 but not 2 years.[21,22] In the clinical setting, it is important to identify persons who are at risk at initial assessment and determine the sensitivity and specificity of such risk factors. To our knowledge, this has not been done previously.

We prospectively followed consecutive persons with whiplash injury, recording pain and symptoms, measuring neck mobility and work capacity of the neck muscles, and assessing health behavior by means of the Millon Behavioral Health Inventory.[23,24] The aim was to identify the role of possible risk factors and determine the sensitivity and specificity of such factors for predicting which patients will de-

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velop late whiplash syndrome. To take traumatic distress into account, we balanced the design of the study by using a control group that had an acute distortion injury distant from the neck. Information on legal issues was obtained 3 to 4 years after injury in the whiplash group.

Patients and methods. *Patients.* From January 6, 1997 to January 5, 1998, persons in Aarhus, Denmark with acute traumatic neck injury were invited to participate in the study if the following criteria were fulfilled: 1) involvement in a motor vehicle accident with a rear hit; 2) preservation of consciousness during collision; 3) no amnesia after the accident; 4) contact with the local emergency unit within 2 days after trauma with complaints of neck pain or headache; and 5) age between 18 and 70 years. Exclusion criteria included 1) previously recorded neck or low-back disorder or head injury; 2) severe headache, migraine, or widespread pain; 3) a record of severe psychiatric disease; and 4) known drug or alcohol abuse. Approval was obtained from the local ethical committee, and the study was conducted in accordance with the Helsinki II declaration. All participants gave informed written consent to participate at first visit.

On the basis of the inclusion criteria, we invited 230 consecutive persons with whiplash injury to participate during a 12-month recruiting period. From this group, 32 individuals were excluded because of chronic low back pain (n = 12), chronic neck pain or whiplash sequelae (n = 7), widespread pain (n = 3), severe chronic disease (n = 6), unconsciousness during accident (n = 3), or noncompliance at first visit (n = 1). Of the 198 individuals remaining after exclusion, 57 subjects did not show up at first examination and 141 were seen at first visit. Of the former, 32 subjects filled in a questionnaire regarding symptoms 6 months after injury, 41 filled a questionnaire after 1 year, and 11 did not respond to any inquiries. Of the latter 141 subjects, mean ± SD ages were 35.0 ± 10.5 years for the 74 women and 33.9 ± 10.5 years for 67 men; nine were lost to follow-up.

Persons with acute ankle distortion (that did not occur during sporting activity) served as control subjects; 141 consecutive persons sustaining an acute ankle distortion seen within 2 days at the Emergency Unit of the Department of Orthopedic Surgery at Aarhus University Hospital and who fulfilled the same inclusion and exclusion criteria as the whiplash group constituted a possible control sample. Sixty-five persons did not respond after written invitation, and 16 did not want to participate because of job or family situation. Twenty persons were excluded because of chronic neck pain (8), shoulder pain, chronic low back pain (5), severe chronic disease (6), and alcohol abuse (1). Forty age- and gender-matched patients with ankle distortion (21 women and 19 men) agreed to participate. No specific treatment was offered, and injured participants used treatments usually offered in Denmark (eg, short-term analgesics, physiotherapy, and mobilization). When the study was conducted, a soft collar was initially offered as standard treatment for use for 7 to 14 days; this is not in agreement with The Quebec Task Force Recommendations.

Methods. The same author (H.K.) interviewed and examined all subjects 1 week and 1, 3, 6, and 12 months after injury. All persons with whiplash injury who were eligible for the study also received a questionnaire concerning legal issues 3 years after injury.

History was taken and neurologic examination performed at the first visit. Patients were instructed to rate their present pain on a visual analogue scale, as part of a McGill Pain Questionnaire,[25,26] from 0 (no pain) to 100 (unbearable pain). In a semistructured interview, all persons were asked if they had experienced within the last 7 days any of 15 nonpainful complaints: exhaustion, anxiousness, forgetfulness, sleep disturbance, irritability, impaired ability to concentrate, imbalance, dizziness, nausea, increased sensitivity to noise, tinnitus, paresthesia in upper limbs, dysphagia, blurred vision, or diplopia or other vision disturbances. Persons with whiplash injury who did not undergo examination and only received questionnaires were asked in the same manner as those seen by the examiner.

Work capacity and handicap was determined by a semistructured interview in which persons with whiplash injury and ankle injury were asked to select one of six items, after 6 months and 1 year:

1. My work capacity is the same as before injury.
2. I work the same hours as before injury, but my tasks have been simplified or reduced due to problems after injury.
3. I have reduced working hours and reduced work capacity due to problems after injury.
4. I have been dismissed from my job or have changed job due to problems after injury.
5. I am in job training due to problems after injury.
6. I have applied for or have received disability pension due to problems after injury.

A person was regarded as handicapped if he or she selected item 3, 4, 5, or 6. Number of days until return to work or daily activities after injury was also obtained.

Persons were instructed to fill out the Millon Behavioral Health Inventory, [23,24] which has 150 "yes" or "no" questions.

Active cervical range of motion (CROM) was assessed by the same examiner (H. K.) with the subject situated in a comfortable chair in a room kept between 20 and 24 °C. A simple CROM instrument (Performance Attainment Associates, Roseville, MN[27-29]) was used to obtain maximal voluntary movement in three different planes (flexion and extension in the sagittal plane, left and right flexion in the coronal plane, and left and right rotation in the horizontal plane, where a magnetic yoke with magnets pointing north was mounted on the shoulders). The CROM device was easily applied. Repeated measurements in control subjects showed acceptable within-tester variability, with a within-subject coefficient of variation of 5.2% (one-way analysis of variance; unpublished observations).

A neck-trainer instrument with a computerized device for measuring maximal force was used to examine muscle strength and static work of neck muscles during submaximal load (60% of maximal voluntary contraction for extension and flexion of the neck). Subjects were placed in the neck-trainer instrument (Neck Exercise Unit, Follo, Norway[30]) and performed the intended movement only once with a small load (1 kg for flexion and 2 kg for extension). When testing maximal voluntary contraction, three measurements each were made for extension (at 15°) and flexion (at 30°). The mean value of the last two measurements was used for determination of the 60% maximal voluntary contraction value on a precalculated scale. The subject had to keep the arm of the neck-trainer instrument in the same position (15° degrees and 30° flexion) while contracting against the 60% maximal-voluntary-contraction load as long as possible. On basis of duration (seconds) and load (Nm) for extension and flexion, a total workload was computed for each person. For the workload test, repeated measurements in control subjects showed a within-subject coefficient of variation of 5.7% (one-way analysis of variance).

Statistics. SPSS for Windows (SPSS Inc., Northbrook, IL) was used for analyzing data. Total active CROM data showed normal distribution in both subjects with whiplash and ankle injuries. Workload data showed a log normal distribution in gender-split data for the groups. For the CROM and workload data sets, mean and SD in control subjects were computed and used to dichotomize variables in persons sustaining whiplash. CROM values (mean ± SD) in control subjects were 361.1 ± 47.2 degrees. Values 2 SD below mean in control subjects were considered as risk factors.

The data from the visual analogue scale (scored from 1 to 100) were treated dichotomously and split in two groups: scores of 0 to 53 (no pain to mild pain) and 54 to 100 (moderate pain to severe pain).[31]

No control subjects had more than six of the 15 possible complaints (listed above), so a cut-off value between six and seven was chosen in the whiplash group: 0 to 6 and 7 to 15.

The Millon Behavioral Health Inventory was analyzed with a scoring program developed for the Institute for Personality Theory and Psychopathology in Denmark. The output was dichotomized. Only if the test showed at least two abnormal scores out of six on a psychometric scale or one out of three on a prognostic dimension scale was it considered a risk factor. Cox regression analysis was chosen to allow censoring of cohort data and to test for time dependency of risk factors, which could not be achieved by multiple regression methods. For the preparation of the Cox regression, time to event (return to work or daily activity in days) was chosen as the time parameter. Eight factors were used in the regression analysis: CROM, workload, pain intensity, number of symptoms, gender, speed difference of cars, age, and body mass index. Speed difference of cars was regarded as a risk factor if the difference was 26 km/h or more (0 to 25 km/hour and 26 to 100 km/h).[32] Age was split after the manner of Radanov and Sturzenegger[21] at 31 years (17 to 30.99 years and 31 to 70 years). Body mass index was dichotomized at 30 kg/m^2 (16 to 29.99 kg/m^2 and 30 to 45 kg/m^2). Log minus log (LML) curves were made for each of the eight factors, and time-dependent covariance of each factor was examined before running the Cox regression analysis. There was no significant time dependency of factors (SPSS time program: $\alpha = 0.05$; $\beta = 0.10$). LML graphs showed parallel curves for the split factors in every plot. Receiver operating characteristic curves were computed for noncategorized data (total CROM, workload, visual analogue scale pain intensity, and number of nonpainful complaints).

Results. Of 141 patients with whiplash injury, 8% had not returned to daily activity after injury and an additional 4% had returned only to modified job functions 1 year after trauma. Recovery from inability to work is shown in figure 1. As can be seen, the majority of patients with whiplash injury had recovered after 1 month. To avoid bias, it was decided a priori to consider persons who had not returned to daily activity or work as nonrecovered or disabled. Basic properties of the patients in the whiplash group (represented by the first value in the comparisons below) and ankle injury group were similar with respect to age (35.6 ± 10.8 versus 34.8 ± 12.0 years), body mass index (24.6 ± 4.6 versus 24.3 ± 3.1 kg/m^2), gender (74 women and 67 men versus 21 women and 19 men), educational level (primary school, 3.6% versus 5.3%; secondary school, 15.2% versus 7.9%; practical education, 56.5% versus 47.4%; university student or graduate, 21.7% versus 36.9%; other, 2.9% versus 2.6%), and marital status (married or common law, 70.9% versus 42.5%; single or divorced, 27.0% versus 55.0%; information not available, 2.1% versus 2.5%).

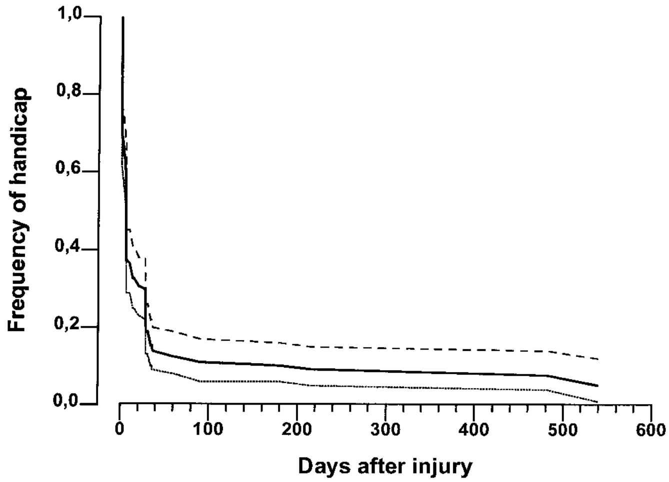

Figure 1. Recovery from handicap after acute whiplash injury. Kaplan–Meier survival plot.

The CROM test predicted handicap after acute whiplash injury with a sensitivity of 73% and a specificity of 91% (table 1). The combined measure of high pain intensity and seven to 15 nonpainful symptoms on the semistructured interview showed an accuracy of 94%, a specificity greater than 99%, but a low sensitivity of 27%. When examining nondichotomized data, there was an inverse relationship between total CROM and pain as well as total CROM and nonpainful complaints, and a positive relationship between total CROM and workload (table 2). There was a significant inverse relationship between workload and pain and between workload and nonpainful complaints. There was a strong correlation between pain and nonpainful complaints (see table 2). Millon Behavioral Health Inventory sum (psychometric scores plus prognostic scores) was not significantly related to total CROM, workload, pain, or to nonpainful complaints (see table 2).

Risk for long-term handicap was increased by a factor of 2.5 (table 3) in persons with reduced cervical mobility after 1 year, and by 2.1 in those with reduced mobility after 6 months (data not shown, but can be obtained from authors). Cox regression analysis showed that other initial factors—pain intensity, number of nonpainful complaints, workload in neck muscles, and psychometric score—did not, as single factors, significantly predict long-term hand-

Table 1 Diagnostic accuracy with different approaches after acute whiplash injury

Risk criteria	Sensitivity, %	Specificity, %	Prevalence, %	PPV, %	NPV, %	Accuracy, %
Between 7 and 15 nonpainful complaints	54.5	83.1	7.8	21.4	95.6	80.9
2 of 6 abnormal psychometric or 1 of 3 abnormal prognostic dimension on MBHI	0.0	89.1	8.2	0.0	90.9	63.8
Workload 2 SD below mean in control subjects	36.4	96.1	7.9	44.4	94.7	90.8
Severe pain (score between 54 and 100 on VAS)	36.4	92.3	7.8	28.6	94.5	87.9
Reduced total CROM (2 SD below mean in control subjects)	72.7	90.8	7.8	40.0	97.5	89.4
Item 1 plus item 4	27.3	99.2	7.8	75.0	94.2	93.6
Items 1, 4, and 5	30.0	99.2	7.9	75.0	94.7	94.1
Item 4 plus item 5	36.4	97.7	7.8	57.1	94.8	92.9
Item 3 plus item 5	36.4	97.7	7.9	57.1	94.7	92.2

Sensitivity is the proportion of nonrecovered subjects who are test positive = (nonrecovered and test positive)/nonrecovered. Specificity is the proportion of recovered subjects who are test negative = (recovered and test negative)/recovered.
Prevalence (estimated from study results) = nonrecovered/total. Positive predictive value (PPV) is the probability that a person with positive test will not recover.
PPV = prevalence × sensitivity/([prevalence × sensitivity] + [1-prevalence] × [1-specificity]).
Negative predictive value (NPV) is the probability that a person with negative test will recover.
NPV = (1-prevalence) × specificity/([1-prevalence] × specificity + prevalence [1-sensitivity]).
Accuracy = (True positives + true negatives)/total.
CROM = cervical range of motion; MBHI = Million Behavioral Health Inventory; VAS = visual analog scale.

icap after whiplash injury at 1 year or 6 months (see table 3). Furthermore, in the Cox regression analysis, gender, speed difference of colliding cars, age, and body mass index did not significantly influence recovery. The types of therapy chosen by patients with whiplash injury at first visit—soft collar (45%), active physiotherapy (3%), passive physiotherapy (6%), manipulation (4%), and weak analgesics (48%)—did not influence long-term recovery. A soft collar was used by 45% initially, by only 3% after 1 month, and not used after 6 months.

To determine the possible influence of legal factors on subsequent handicaps, we recorded the number of lawsuits initiated within the first month after injury. As shown in table 3, a lawsuit within the first month after whiplash injury was not a significant risk factor. In total, 38% (43/113) of responders initiated a lawsuit during a 3-year time span; in 18% (20/113) this was initiated during the first month after injury.

For nondichotomized data, the computed receiver operating characteristic curves showed a significant relation-

Table 2 Correlation matrix between noncategorized risk factors

Initial values	MBHI sum	Nonpainful complaints	Total CROM	Pain
Workload (log)				
Pearson correlation coefficient	−0.07	−0.39	0.51	−0.50
Sig. (2-tailed)	0.51	2.0×10^{-6}	2.7×10^{-10}	6.6×10^{-10}
n	104	137	137	137
MBHI sum (sqrt)				
Pearson correlation coefficient		0.18	0.02	0.15
Sig. (2-tailed)		0.06	0.81	0.12
n		105	105	105
Nonpainful complaints				
Pearson correlation coefficient			−0.38	0.41
Sig. (2-tailed)			3.1×10^{-6}	5.1×10^{-7}
n			141	141
Total CROM				
Pearson correlation coefficient				−0.51
Sig. (2-tailed)				5.9×10^{-11}
n				141

CROM = cervical range of motion; MBHI = Million Behavioral Health Inventory.

Table 3 Cox regression analysis of possible risk factors after acute whiplash injury

	Sig.	Exp (B) (95% CI)
Total CROM	0.01	2.53 (1.26–5.11)
Workload	0.39	1.60 (0.54–4.71)
Pain (VAS)	0.14	1.78 (0.82–3.84)
Number of symptoms	0.13	1.48 (0.90–2.45)
Gender	0.89	1.03 (0.71–1.48)
Speed difference ≥26 k/h	0.45	1.21 (0.74–1.97)
Age ≥31	0.99	1.00 (0.69–1.45)
BMI ≥30 kg/m^2	0.33	1.36 (0.73–2.54)
Lawsuit during 1st month*	0.15	1.52 (0.86–2.69)

* Cox regression with 111 responding participants after 3 years, with factors 1–4 and 9 included; total cervical range of motion (CROM) was the only significant factor in the analysis.

BMI = body mass index.

ship between total CROM and nonrecovery (area under the curve = 0.88; 95% CI, 0.71 to 1.00; p = 0.0004), figure 2. In addition, workload (area under the curve = 0.73; 95% CI, 0.53 to 0.93; p = 0.02), pain intensity (area under the curve = 0.82; 95% CI, 0.68 to 0.96; p = 0.01), and number of nonpainful complaints (area under the curve = 0.81; 95% CI, 0.69 to 0.94; p = 0.01) were also significantly related to nonrecovery (p values less than 0.05 imply that the area under the curve is significantly higher than 0.5). A perfect test with 100% sensitivity and 100% specificity would yield an area under the curve of 1.0. The Millon Behavioral Health Inventory did not detect any persons at risk (sensitivity of 0%).

Discussion. This prospective study showed that long-term handicap after whiplash injury is predictable by measuring neck mobility in a standardized manner, by means of a CROM device. Further accuracy is added when this test is supplemented with assessment of pain intensity and nonpainful complaints.

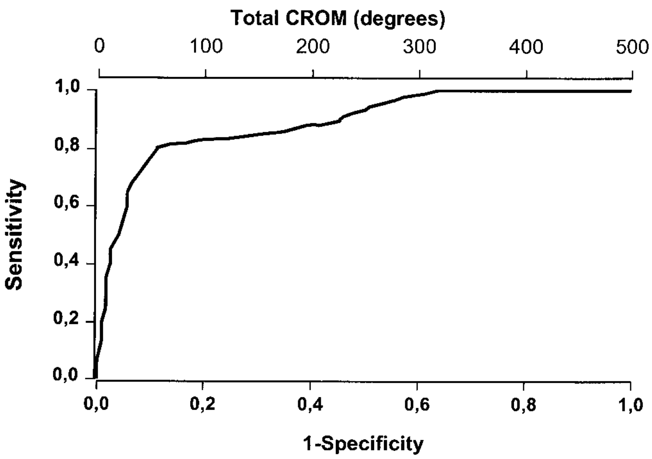

Figure 2. Prediction of 1-year handicap after whiplash injury. Receiver operating characteristic curve for total cervical range of motion (CROM).

In an earlier report,[33] we showed that patients with whiplash injury have reduced neck mobility until 3 months after injury, which is inversely related to neck pain intensity. In a Swiss study, passive neck mobility was examined after acute whiplash injury, and data suggested neck restriction was a risk factor for poor outcome 1 year after injury, but not 2 years after.[21,34] This study did not measure neck restriction, but it was claimed to be present or not present on the basis of a dichotomous judgment.

In the current study, measurement of CROM and determination of outcome was done by the same investigator. Thus, these parameters are potentially open for bias. We consider this unlikely, however, for three reasons: 1) determination of return to daily activity was based on a standardized semistructured interview and questionnaire administered 6 and 12 months after injury, whereas the CROM test was carried out before this, at a time when the outcome was unknown; 2) by choosing an assessor-independent parameter such as work capacity as an outcome measure, we felt that such parameter was not sensitive to investigator bias; and 3) the CROM test was found to be reproducible, with a low variation coefficient, and only CROM values that were more than 2 SD below the mean value in the control subjects with ankle injury were considered as risk values. Accordingly, bias is unlikely to influence the present data.

From the current quantitative assessment, it was shown that poor prognosis is related to reduced neck mobility and high initial pain intensity. The sensitivity and specificity were 73% and 91%. Although specificity increases with the addition of other factors, there is a concomitant decrease of sensitivity, suggesting that measurement of cervical neck mobility early after whiplash injury may be an indicator for subsequent problems. The design of the study did not permit measurement of neck mobility, neck strength, and neck endurance before injury, but according to the exclusion criteria employed, it is unlikely that participants had a previous neck disease. The inclusion of a sex- and age-matched control group ensured that unnoticed neck disability, if present, would be equally represented in both groups. The current finding that reduced neck mobility is related to poor outcome does not necessarily imply that cervical injury is responsible for long-term symptoms. Other factors such as reduced pain threshold and psychological, social, and legal issues may also play a role. For example, results from Canada[10,11] show that litigation procedures may influence recovery. A change in Saskatchewan, Canada from a tort compensation system (injured parties could sue for pain and suffering) to a no-fault system (providing an initial one-and-for-all payment) reduced the number of claims by 43% in men and 15% in women.[10] We would also expect a Danish population to be susceptible to legislative and compensation issues with regard to persistence of pain and other complaints during an on-going claim. In the present study, however, persons with whiplash injuries who began a lawsuit within 30 days after injury were not at higher risk for handicap than other participants (see table 3). We have shown (Kasch et al., unpublished observations), that symptomatology is highly influenced by questioning and assessment. Thus, the control group reported "whiplash-like" symptoms such as headache and neck, shoulder, arm, and low back pain when asked several times about having these symptoms. These findings suggest that focus and attention may play a role in the development of symptoms after whiplash injury.

Although the current study indicates that testing of CROM in patients with acute whiplash injury predicts subsequent handicap in terms of reduced daily activity, there is at present no gold standard treatment to avoid developing handicap. In a Norwegian study that randomly assigned patients with acute whiplash injury to soft collar or early mobilization,[35] reduced long-term pain and complaints was observed in the early mobilization group. A Swedish 6-month follow-up study with three treatment groups showed that mobilization within 96 hours could reduce pain significantly, more than mobilization initiated after 2 weeks or standard information (leaflet or instructions).[36] These findings are in concordance with The Quebec Task Force recommendations for early mobilization after injury.[11] In a 1-year follow-up study of 62 patients with chronic, nonspecific neck pain, significant pain relief and reduced disability were found only in patients receiving active treatment.[37] However, there was no parallel increase in CROM, suggesting that CROM is clinically less useful when monitoring chronic, nonspecific neck pain. In contrast, we found a significant inverse relationship between pain and CROM and between nonpainful complaints and CROM (see table 2) in patients with acute whiplash. The fact that we are able to identify persons at risk in the early phase after whiplash injury using the CROM test indicates the need for future intervention studies, with early onset of treatment in persons at risk for long-term disability after acute whiplash injury.

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Temporal lobe epilepsy due to hippocampal sclerosis in pediatric candidates for epilepsy surgery

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Article abstract—*Objective:* To characterize the clinical, EEG, MRI, and histopathologic features and explore seizure outcome in pediatric candidates for epilepsy surgery who have temporal lobe epilepsy (TLE) caused by hippocampal sclerosis (HS). *Methods:* The authors studied 17 children (4 to 12 years of age) and 17 adolescents (13 to 20 years of age) who had anteromesial temporal resection between 1990 and 1998. *Results:* All patients had seizures characterized by decreased awareness and responsiveness. Automatisms were typically mild to moderate in children and moderate to marked in adolescents. Among adolescents, interictal spikes were almost exclusively unilateral anterior temporal, as opposed to children in whom anterior temporal spikes were associated with mid/posterior temporal, bilateral temporal, extratemporal, or generalized spikes in 60% of cases. MRI showed hippocampal sclerosis on the side of EEG seizure onset in all patients. Fifty-four percent of children and 56% of adolescents had significant asymmetry of total hippocampal volumes, whereas the remaining patients had only focal atrophy of the hippocampal head or body. Subtle MRI abnormalities of ipsilateral temporal neocortex were seen in all children and 60% of adolescents studied with FLAIR images. On histopathology, there was an unexpectedly high frequency of dual pathology with mild to moderate cortical dysplasia as well as HS, seen in 79% of children and adolescents. Seventy-eight percent of patients were free of seizures at follow-up (mean, 2.6 years). A tendency for lower seizure-free outcome was observed in patients with bilateral temporal interictal sharp waves or bilateral HS on MRI. The presence of dual pathology did not portend poor postsurgical outcome. *Conclusions:* TLE caused by HS similar to those in adults were seen in children as young as 4 years of age. Focal hippocampal atrophy seen on MRI often was not reflected in total hippocampal volumetry. Children may have an especially high frequency of dual pathology, with mild to moderate cortical dysplasia as well as HS, and MRI usually, but not always, predicts this finding. Postsurgical seizure outcome is similar to that in adult series.

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Hippocampal sclerosis (HS) is an infrequent etiology in pediatric candidates for temporal resection. In children, low-grade tumors and malformations of cortical development are more common.[1] Previous pediatric epilepsy surgery series[2-5] have included each only six to nine patients with HS. However, larger numbers have been reported in nonsurgical series.

In MRI studies of pediatric patients with temporal lobe epilepsy (TLE), HS was noted in 21% of patients 15 years of age or younger with new-onset TLE[6] and 57% of patients 2 to 17 years of age with refractory temporal lobe epilepsy.[7,8] The latter incidence rate is in keeping with earlier reports of 60% incidence of histopathologically demonstrated HS in children before the advent of MRI[9] in surgical series. HS has been seen on MRI in infants as young as 4 months[10] and 2 years[6,11] of age.

Early surgery for intractable epilepsy may improve cognitive and psychosocial outcome.[12,13] However, few data are available about the clinical, EEG,

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