J Rehabil Med 2007; 39: 405–411

ORIGINAL REPORT

ONE-YEAR FOLLOW-UP OF MILD TRAUMATIC BRAIN INJURY: COGNITION, DISABILITY AND LIFE SATISFACTION OF PATIENTS SEEKING CONSULTATION

Britt-Marie Stålnacke[1], Eva Elgh[2] and Peter Sojka[1]

From the Department of Community Medicine and Rehabilitation, [1]Rehabilitation Medicine and [2]Geriatrics, Umeå, Sweden

Objective: **To investigate cognitive function, symptoms, disabilities and life satisfaction of patients with mild traumatic brain injury who accepted consultation one year post-trauma.**
Design: **Prospective study.**
Patients: **Sixty-nine patients (16 accepted the consultation offered, 53 declined).**
Methods: **At follow-up, the patients answered questionnaires about symptoms, disabilities (RHFUQ) and life satisfaction (LiSat-11). The patients who underwent consultation and their healthy control subjects were administered a neuropsychological evaluation.**
Results: **In the group undergoing consultation, the number of cognitive tests with outcomes below cut-off limits (–1.5 SD) was statistically significantly higher compared with a control group (21 tests in 11 patients vs 8 tests in 7 control subjects; $p = 0.025$). The number of patients with one or more disability was statistically significantly higher among patients with consultation than without (94% and 34%, respectively; $p < 0.001$). Total RHFUQ score was statistically significantly higher for the group with consultation than without (5.9 ± 3.7 and 1.1 ± 2.3, respectively, $p < 0.001$). The group with consultation exhibited a lower level of life satisfaction (41.5 ± 10.4 vs 45.8 ± 13.8 for the non-consulting group; $p = 0.057$).**
Conclusion: **The high frequency of occurrence of disabilities and lower cognitive functioning, together with the lower level of life satisfaction, appear to characterize patients choosing consultation 1 year post-injury. This highlights the importance of offering consultation for persons suffering mild head injuries.**

Key words: traumatic brain injury, head trauma, brain concussion, post-concussion symptoms, life satisfaction, neuropsychological tests.

J Rehabil Med 2007; 39: 405–411

Correspondence address: Peter Sojka, Department of Community Medicine and Rehabilitation (Rehabilitation Medicine), Bldg 9A, Umeå University Hospital, Umeå University, SE-901 85 Umeå, Sweden. E-mail peter.sojka@clinphys.umu.se

Submitted March 15, 2006; accepted December 11, 2006

INTRODUCTION

For a long time, the term "silent epidemic" has been used to encompass mild traumatic brain injury (MTBI) complex (1). This term implies that the condition is common, but that there is a lack of appropriate interest from the general public and the scientific community. The prevalence of MTBI may be illustrated by statistics from a comprehensive population-based study of the incidence of traumatic brain injuries, published by Andersson et al. (2), which revealed a total incidence of traumatic brain injury of 545/100,000, with mild head injuries constituting about 88%. Mild head injuries accordingly exceed by far the combined figure of incidence (27.4/100,000) (3) for several common neurological diseases, e.g. Parkinson's disease, multiple sclerosis and myasthenia gravis. As well as describing mild head injuries as a "silent epidemic", one could add the term "chronic condition", as a considerable number of patients with MTBI (14–50%) (4–6) may exhibit persisting symptoms, disabilities and a reduction in life satisfaction, with an impact on their professional and private lives (6–8).

In spite of the exceptionally high frequency of occurrence of MTBI and the duration of its consequences, there are no generally accepted management routines (9). One reason for this is a considerable confusion about the cause of long-term sequelae of MTBI. There has been a protracted debate on the relative significance of biological and psychological variables (10), the contribution of litigation and malingering (11), the importance of expectations (12) and coping aspects (13). Another factor of importance is that there may be a number of concomitant co-morbidities (e.g. depression and anxiety disorders (3), post-traumatic stress-disorder (14), whiplash-associated disorders and pain conditions (15)), exhibiting several similar features, which makes it difficult to delineate the sequelae of mild head injury. Nevertheless, a cornerstone in the debate has been, and still is, the question of whether neurological damage (damage to brain tissue) is the main cause of persisting late symptoms and disabilities after mild head injury.

In a previous prospective study we investigated subjects with MTBI with a follow-up one year after the trauma (7, 16). In these papers we described symptoms and serum levels of S-100B, neuron-specific enolase (NSE) in acute stage and data on symptoms, disabilities and life satisfaction at follow-up. Out of the 69 patients who participated in the follow-up, a sub-group of 16 accepted a consultation appointment for further management of the head injury. Since low cognitive performance might indicate that neurological damage has occurred, we decided to investigate cognitive performance. Thus, the subjects who accepted consultation were examined using a battery of neuropsychological

 ISSN 1650-1977
DOI: 10.2340/16501977-0057

tests and the results were compared with the outcomes of the same tests obtained for a control group consisting of healthy subjects. Moreover, the patients who accepted consultation were compared with those who did not accept consultation with respect to the levels of the biochemical markers of brain damage (S-100B, NSE) and to post-concussion symptoms, disabilities and aspects of life satisfaction.

METHODS

A detailed description of the methods used in the present study and of the characteristics of the patient population (demographics, accidental data, symptoms, etc.) is included in our previous papers (7, 16). This Methods section is therefore restricted to a brief summary of the general methods used in the study and only the aspects specific for the data presented in this paper is expanded on.

Patients with head trauma (MTBI; aged over 18 years, Glasgow Coma Scale (GCS) 13–15, loss of consciousness less than 30 minutes), admitted for observation at the Umeå University Hospital, were invited to participate in the study. Venous blood samples were collected on admission (after the patients had given their informed consent) and again about 7 hours later, for the analysis of serum concentrations of biochemical markers of brain tissue damage, S-100B and NSE. Information on trauma history, symptoms and signs during pre-hospital and hospital time periods was gathered from the ongoing injury and trauma register, from ambulance and hospital records and from a structured interview performed by a research nurse before discharge from the hospital. The interview included questions about previous concussion, alcohol and medication use, etc. Serum S-100B and NSE were analysed using immunoluminometric assays LIAISON Sangtec 100 and LIAISON NSE Sangtec (Sangtec Medical, Bromma, Sweden). Complete data were obtained for 88 patients.

The study was approved by the ethics committee of Umeå University.

Follow-up

A follow-up was performed 15 (SD 4) months after the injury. A set of questionnaires was sent by post to 88 patients, depicting post-concussion symptoms (presence or absence of symptoms corresponding to items of Rivermead Post-Concussion Symptoms Questionnaire (RPQ) (17), disabilities (Rivermead Head Injury Follow Up Questionnaire (RHFUQ) (18)), and level of life satisfaction (LiSat-11) (19). To the RHFUQ, which is constructed as a self-report measure of functional and psychosocial disability caused by the MTBI, an extra question was added: "Do you wish to get a consultation appointment regarding further management?"

Sixty-nine patients responded to the questionnaires and participated in the follow-up one year after the injury. Nineteen patients did not reply. Responders and non-responders were compared (variables: age, gender, employment, previous concussion, external cause of the accident, symptoms on admission and at discharge, loss of consciousness, amnesia and alcohol intake) and they differed only with respect to alcohol intake (i.e. a significantly larger proportion of the non-participants had been under the influence of alcohol at the time of trauma, $p = 0.016$). The pooled demographic data for all 88 patients (i.e. 69 responders and 19 non-responders) are presented in Stålnacke et al. (7: Table I). Of the 69 patients participating in the follow-up, 16 accepted a consultation appointment for further management of the head injury (7 men and 9 women) and this group of patients is denoted "consultation-seeking group" (CS group). The group of patients declining a consultation appointment ("non-consultation-seeking group", non-CS group) comprised 53 patients (32 men and 21 women). Both groups were similar with respect to demographics, accidental data and symptoms (apart from headache at discharge, which was more commonly reported by the patients in the CS group).

Table I. *Results of the neuropsychological tests.*

	CS group	Control group	p-value
Colour word test			
Process (s)	73.47 (11.39)	65.66 (13.45)	0.020
Interference (%)	53.63 (14.36)	60.63 (23.72)	0.173
Adaptation (%)	5.2 (6.23)	3.03 (7.5)	0.426
Fingertapping (APT)			
Right	6.06 (0.93)	5.88 (0.82)	0.363
Left	5.36 (0.62)	5.6 (0.43)	0.147
Alternation right	3.15 (1.03)	3.23 (0.96)	0.820
Alternation left	2.77 (0.92)	3.11 (0.97)	0.460
Alternation right/left	3.31 (0.95)	3.67 (0.66)	0.334
Reaction time (APT)			
Auditory (s)	219.99 (32.65)	216.72 (43.33)	0.394
Visual (s)	226.41 (50.83)	219.50 (56.47)	0.307
Two choice left (s)	289.71 (54.57)	283.02 (65.53)	0.650
Two choice right (s)	276.62 (36.12)	274.57 (52.38)	0.955
Inhibition left (s)	518.42 (211.90)	452.70 (134.07)	0.173
Inhibition right (s)	593.49 (413.94)	437.41 (150.18)	0.069
Trail making test A (s)	41.47 (13.54)	31.13 (11.68)	0.048
Trail making test B (s)	82.40 (23.81)	67.00 (30.56)	0.053
PASAT			
2.4 (s)	31.60 (14.33)	31.27 (13.13)	0.955
2.0 (s)	30.29 (12.20)	27.47 (10.48)	0.900
1.6 (s)	22.93 (8.65)	26.80 (20.04)	0.600
1.2 (s)	17.78 (5.95)	15.87 (5.74)	0.753
Total time (s)	19.30 (7.81)	2.13 (8.78)	0.875
Average time (s)	4.87 (2.03)	5.28 (2.19)	0.875
Errors	5.79 (7.27)	7.20 (2.86)	0.307

APT: automated psychological test system; PASAT: aced auditory serial-addition test; CS: consultation-seeking.

Patients in the CS group were given appointments and asked for their informed consent regarding subsequent neuropsychological assessment. All the patients in the CS group reported persistent symptoms after injury as the main reason for accepting the appointment. One of the authors (B-MS) examined the patients in the CS group and found that neurological examinations were normal for all patients. Given the relatively small size of the patient sample, it was not possible to select a corresponding control group from among the non-CS patients matched for age, gender and educational level. Thus, for comparison purposes (regarding level of life satisfaction, disabilities, neuropsychological variables and presence/absence of post-concussion symptoms, etc.), we chose as our control population a group ($n = 16$ (CL group)) of healthy subjects (with no history of head trauma during the last 2 years) which was matched to the CS group with respect to gender, age (± 2 years) and educational level. The control subjects were chosen by the authors via personal contacts. The control subjects were then tested with the same battery of neuropsychological tests (see below) and they completed the same questionnaires as the CS group except RPQ and RHFUQ (see above). For the items of RPQ and RHFUQ the control subjects had to mark presence/absence of symptoms and disabilities at the time of completing these questionnaires, as no head trauma had occurred in the control subjects).

Neuropsychological testing

Both the patients in the CS group and the subjects in the CL group were administered a neuropsychological evaluation selected specifically for persons with MTBI, with focus on attention, speed and executive function. They also filled in the Montgomery-Åsberg Depression Rating Scale (MADRS) (20). One of the patients was unable to perform the tests due to chronic alcoholism. All evaluations were executed by an experienced consultant in clinical neuropsychology (EE), who also made an evaluation of the person's effort in the test situation.

Altogether, each patient underwent 5 different tests. The evaluation included the paced auditory serial-addition test (PASAT) (21), finger tapping and reaction time test from the automated psychological test system (APT) (22), Trail making test (TMT) (23) and Colour word test (CWT) (24).

The PASAT was developed in order to assess the rate of information processing or the amount of information that can be handled at one time (21). The subject is required to comprehend an auditory input, respond verbally and inhibit encoding of his/her own response while attending to the next stimulus in a series. The task must be effectuated at an externally determined pace. Instructions were given in Swedish, using a pre-recorded tape (with a male speaker) played on a tape recorder. Each person was tested individually. There was one practice list of 10 single digits recorded at 2.4-second intervals, followed by 4 trials of 61 digits each (numbers 1–9 used in the same random order in each trial). The trials have been recorded at a rate of one digit every 2.4, 2.0, 1.6 and 1.2 seconds. The duration of each digit is approximately 0.4 seconds. The PASAT thus increases processing demands by increasing the speed of stimulus input and it requires both rapid processing and shifting mental control.

The APT is a multi-language, comprehensive computerized neuropsychological test battery (22). The finger tapping test assesses the motor speed in 5 sub-tests: finger tapping with the right index finger, finger tapping with the left index finger, alternation between the right index and middle fingers, alternation between the left index and middle fingers, and alternation between the right and left index fingers.

The reaction time test comprises 4 sub-tests: simple auditory reaction time (RT) responding with the dominant index finger, simple visual RT responding with the dominant index finger, two-choice visual RT (a visual signal to the right or to the left of a central fixation point, responding with the index finger of the corresponding side), two-choice visual RT with response inhibition if an auditory signal is co-presented with a visual signal (Go-Nogo test) (22).

The TMT (23) is included in the Halstead-Reitan Battery and was originally part of the Army Individual Test Battery. TMT has previously been used in several studies of MTBI (25, 26). TMT is a test of complex visual scanning with a motor component. The test is given in 2 parts, A and B. The subject must first draw lines to connect consecutively numbered circles on a worksheet (part A) and then alternately connect consecutively numbered and lettered circles on another worksheet (27).

The CWT (24) is a Swedish version of the Stroop test (which measures the relative speeds of reading names of colours, naming colours, and naming colours used to print an incongruous colour name (e.g. the colour red is used to print the word "blue"). The last task requires one to override a reading response. This conflict interference is called the Stroop test and has traditionally been viewed as a measure of executive functioning involving cognitive inhibition and different types of attention. Three types of observations are presented: (*i*) process speed, (*ii*) interference and (*iii*) adaptation. A total judgement of all 3 sub-tests was made.

For a clinical evaluation, raw scores for each test was transformed to standardized scores according to the test manuals and, when possible, with respect to sex, age and educational level. The result of each test was considered to be lowered if the score was 1.5 SD below average for all tested subjects (both patients and healthy control subjects). Lezak et al. (27) has presented a classification system for ability levels based on a statistically defined range of scores. Average performance is according to this mean ± 0.6 SD, low average –0.6 to –1.3 SD and borderline –1.3 to –2.0 SD. We have chosen –1.5 SD as a cut-off level score for lowered test performance, which is commonly accepted in clinical practice.

Statistics

All statistical analyses were performed using SPSS, version 12.0.1 for Windows. As the majority of the investigated variables were not normally distributed, evaluation was made with non-parametric tests both for independent (Mann-Whitney test) or related (Wilcoxon signed-rank test) samples of variables and Spearman's correlation coefficients were calculated for the analysis of bivariate correlations). Categorical variables were compared using the Pearson χ^2 test. For the study of the complex relationship between a dependent variable and independent variables, binary logistic regression analysis was used. For categorical variables the dependent variable was dichotomized and coded as a binary variable (1 = patients with lowered cognitive functioning and 0 = patients without lowered cognitive functioning, respectively) and logistic regression analysis was applied. Stepwise forward multiple regression analysis was performed using $p < 0.01$ for entry limit and $p > 0.10$ for removal limit. The statistical significance level was set at 0.05.

RESULTS

Comparison between CS and CL groups

Neuropsychological assessment. Overall, the patients in the CS group performed less well than the control subjects (CL group) (Table I). In the CS group, the results in 21 sub-tests (in 11 patients) were more than –1.5 SD below the average, see Methods), while the results in only 8 sub-tests (in 7 patients) in the CL group were 1.5 SD below average (χ^2 test, $p = 0.025$).

Depression. As depression may bias a patient's performance in a range of neuropsychological tests, all CS group and CL group subjects also filled in the depression scale MADRS. Interestingly, the mean values of MADRS for the CS group and CL group were very close (CS group: 0.19 (SD 0.41), range: 0–1; CL group: 0.19 (SD 0.54), range: 0–2; $p = 0.809$) and they indicate no depression in any patient.

Occurrence of post-concussion symptoms. The presence of post-concussion symptoms was assessed using questions from the RPQ (Table II). No statistically significant difference was found between the number of symptoms reported by the CS group (mean: 3.62 (SD 4.57), range: 0–14) and the CL group

Table II. *Frequency of occurrence of post-concussion symptoms at follow-up.*

	CS group $n = 16$ (%)	Non-CS group $n = 53$ (%)	Control group $n = 16$ (%)
Headache	8 (50)	7 (13)	1 (6)
Noise sensitivity	2 (12)	1 (2)	1 (6)
Dizziness	5 (31)	8 (15)	2 (12)
Nausea/vomiting	2 (12)	1 (2)	0 (0)
Sleep disturbance	3 (19)	3 (6)	5 (31)
Fatigue	7 (44)	7 (13)	2 (12)
Irritability	5 (31)	4 (7)	2 (12)
Feeling depressed	3 (19)	4 (7)	1 (6)
Feeling frustrated	3 (19)	4 (7)	0 (0)
Poor memory	4 (25)	8 (15)	4 (25)
Poor concentration	3 (19)	8 (15)	1 (6)
Taking longer to think	3 (19)	7 (13)	1 (6)
Blurred vision	4 (25)	3 (6)	0 (0)
Sensitivity to light	4 (25)	4 (7)	1 (6)
Double vision	0 (0)	1 (2)	0 (0)
Restlessness	3 (19)	5 (9)	0 (0)
Number of symptoms, mean (SD)	3.6 (4.6)	1.4 (2.5)	1.3 (1.7)

CS: consultation-seeking.

(mean: 1.31 (SD 1.74), range: 0–5 ($p = 0.149$). In the CS group, the most common symptoms were: headache (reported by 50% of the patients), fatigue (44%) and irritability (31%). In the CL group, sleep disturbance was reported by 31%, poor memory by 25% and fatigue by 12% of the subjects.

Disability. The level of disability at follow-up was measured by the RHFUQ (the patients were asked to compare themselves with how they were before the accident/injury) (see Table III).The controls reported presence or absence of disability items. One disability or more on the RHFUQ was reported by 15 patients (94%) in the CS group and by 2 subjects (12%) in the CL group. Statistical analysis revealed a statistically significant difference ($p < 0.001$) between the number of disability items reported by the CS group (mean: 5.87 (SD 3.68)) and the number of disability items reported by the CL group (mean: 0.19 (SD 0.75)).

Life satisfaction. Life satisfaction was assessed at follow-up using the LiSat-11 questionnaire. The levels of the separate items of LiSat-11 are shown in Table IV. The CS group exhibited statistically significantly lower total scores of LiSat-11 (41.50 (SD 10.39); maximum possible score = 66), compared with the CL group (52.65 ± 5.91, $p = 0.002$). Comparisons of rating revealed a statistically significant difference between the CS group and the CL group for the items: life as a whole, vocation, leisure, family life, somatic health and psychological health.

Comparison between CS and non-CS groups

Occurrence of post-concussion symptoms. One year after the injury, one or more of the post-concussion symptoms on the RPQ was reported by a majority of the patients belonging to the CS group (70%), but only by 38% of the non-CS group (Table II). Statistical analysis revealed a statistically significant difference ($p = 0.021$) between the number of symptoms reported by the CS group (mean: 3.62 ± 4.57, range: 0–14) and the non-CS group (mean: 1.41 (SD 2.52), range: 0–9). In the CS group the most common symptoms were: headache (reported by 50% of the patients), fatigue (44%) and irritability (31%), while patients in the non-CS group rated dizziness (15%), poor memory (15%) and poor concentration (15%) as the most common symptoms.

During the time period between the initial head injury and the follow-up, one patient in the CS group and 2 in the non-CS group sustained another MTBI. However, all patients in the CS group and 25 (47%) of the patients in the non-CS group ascribed their symptoms at follow-up to the first MTBI.

Disability. At least one disability item on the RHFUQ was reported by 15 patients (94%) in the CS group and by 18 patients (34%) in the non-CS group (Table III). The total RHFUQ score (16.8 (SD 11.7), maximum disability score = 40) in the CS group was statistically significantly higher ($p < 0.001$) compared with the non-CS group (3.4 (SD 7.3)). Statistical analysis revealed a statistically significant difference ($p < 0.001$) between the number of disability items reported by the CS group (mean: 5.87 (SD 3.68)), and the non-CS group (mean: 1.12 (SD 2.31)). The most frequently reported changes in the CS group were on the disability items "ability to enjoy previous leisure activities"(reported by 81% of the patients), "finding work more tiring" (75%) and "ability to participate in previous social activities" (69%). In the non-CS group the items "finding work more tiring" (23%), "ability to maintain previous standard of workload " (21%) and "ability to enjoy previous leisure activities" (15%) were the most frequently reported alterations.

Life satisfaction. The level of life satisfaction was generally lower in the CS group than in the non-CS group. The CS group exhibited close to statistically significantly ($p = 0.057$) lower total scores of LiSat-11 (41.50 (SD 10.39); maximum possible score = 66) compared with the non-CS group (45.81 (SD

Table III. *Rivermead Head Injury Follow Up Questionnaire (RHFUQ).*

Frequency of occurrence of disabilities at follow-up	CS group $n = 16$ (%)	Non-CS group $n = 53$ (%)
Ability to participate in conversation with one person	7 (44)	4 (7)
Ability to participate in conversation with 2 or more people	8 (50)	6 (11)
Performance of routine domestic activities	9 (56)	3 (6)
Ability to participate in previous social activities	10 (62)	4 (7)
Ability to enjoy previous leisure activities	13 (81)	8 (50)
Ability to maintain previous standard of workload	11 (69)	11 (21)
Finding work more tiring	12 (75)	12 (23)
Relationship with previous friends	10 (62)	3 (6)
Relationship with partner	8 (50)	4 (7)
Ability to cope with family demands	8 (50)	5 (9)
Number of disability items, mean (SD)	5.9 (3.7)	1.1 (2.3)
Total score of RHFUQ, mean (SD)	16.8 (11.7)	3.4 (7.3)

CS: consultation-seeking.

Table IV. *Comparison of ratings of life satisfaction (items of LiSat-11) between CS group on the one hand and the non-CS group and control group on the other hand.*

	Non-CS-group vs CS group	Non-CS group (n = 52)	CS group (n = 16)	Control group (n = 16)	Control group vs CS group
Item of LiSat-11	p-value	Mean	Mean	Mean	p-value
Life as a whole	0.010	4.6 (0.9)	3.6 (1.5)	4.7 (0.7)	0.043
Vocation	0.042	4.1 (1.0)	3.2 (1.5)	4.9 (0.6)	0.002
Economy	0.298	4.0 (1.4)	3.6 (1.4)	4.2 (0.7)	0.323
Leisure	0.021	4.3 (1.1)	3.1 (1.8)	4.9 (0.9)	0.010
Contacts	0.215	4.6 (1.0)	4.1 (1.5)	5.0 (0.8)	0.086
Sexual life	0.377	4.1 (1.3)	3.7 (1.4)	4.6 (0.8)	0.166
ADL	0.871	5.3 (0.9)	5.4 (0.6)	5.6 (0.8)	0.270
Family life	0.014	4.8 (1.3)	3.9 (1.5)	5.2 (0.8)	0.006
Partner	0.070	4.8 (1.4)	4.0 (1.6)	5.0 (0.9)	0.067
Somatic health	0.023	4.8 (1.1)	3.7 (1.7)	5.3 (0.7)	0.008
Psychological health	0.010	4.8 (1.2)	3.9 (1.4)	5.1 (0.7)	0.011

CS: consultation-seeking; ADL: activities of daily living.

13.84)). The levels of the separate items of LiSat-11 are shown in Table IV. Interestingly, a statistically significant difference between the CS group and the non-CS group was found on the same items of life satisfaction as between the CS group and the CL group (life as a whole, vocation, leisure, family life, somatic health and psychological health).

Serum concentrations of S-100B and NSE. No statistically significant difference was found with respect to serum concentrations of S-100B and NSE when patients in the CS group were compared with patients in the non-CS group (S-100B sample 1: $p = 0.831$, S-100B sample 2: $p = 0.106$, NSE sample 1: $p = 0.597$, NSE sample 2: $p = 0.539$).The serum concentrations of S-100B and NSE were statistically significantly correlated in the non-CS group: S-100B sample 1 and NSE sample 1 ($r = 0.301$, $p = 0.030$). In the CS group no significant correlations between S-100B and NSE were found. To study whether serum levels of S-100B and NSE could predict cognitive deficits at follow-up, we performed a logistic regression analysis. (Dependent variable: patients with lowered cognitive functioning = 1, patients without lowered cognitive functioning = 0). Independent variables were: S-100B sample 1, S-100B sample 2, NSE sample 1 and NSE sample 2. No statistically significant association was found between patients with lowered cognitive functioning at follow-up and concentrations of S-100B and NSE.

DISCUSSION

Patients who accepted a consultation appointment (CS group) exhibited lower levels of cognitive performance in comparison with a control group consisting of matched healthy subjects (CL group) at follow-up one year after the injury. Persistent post-concussion symptoms were reported more frequently by patients in the CS group than those in the non-CS group. The level of disability and life satisfaction was generally lower in the CS group compared with the CL group and the non-CS group.

Comparison between CS and CL groups

Neuropsychological assessment. At a group level the CS group showed low outcome on neuropsychological tests one year after the injury. Although cognitive symptoms are most common early after the head injury (3), long-term neuropsychological impairments have been reported after MTBI up to 6 months after trauma (28). The patients in the present study only underwent neuropsychological tests at follow-up, but as their results were lower in general compared with the healthy control group (carefully matched with respect to age, gender and educational level), the results may indicate that the patients at the time of follow-up suffered from cognitive impairments.

Post-concussion symptoms. At follow-up most patients in the CS group were still suffering from post-concussion symptoms on the RPQ and they ascribed the presence of symptoms to the head injury. However, when the number of symptoms reported by the patients in the CS group and the CL group were compared, no statistically significant difference was found. Moreover, neither the CS group nor the CL group in our study exhibited scores on the depression scale MADRS indicating depression for any subject. In this context it is also important to notice that symptoms reported after a concussion/MTBI are not specific for MTBI; they are also frequently reported by healthy people (29), and, for example, by patients with chronic pain (30).

Disability. The level of disability was assessed by the RHFUQ, an instrument designed for patients with MTBI (18). Most patients in the CS group (94%) and 2 subjects in the CL group reported at least one disability on the RHFUQ. In our study, disability in the CS group was reported more frequently than in a previous study of patients with MTBI (51%) one year after injury (31). However, for estimating the disability level, Thornhill et al. (31) used the Glasgow Outcome Score (GOS), which is a widely employed 5-point scale (from "Death" to the highest level "Good recovery") for overall outcome in patients with head injury. "Good recovery" GOS does not necessarily imply absence of difficulties in, for example, ability to cope with family demands or ability to participate in previous social activities, which are items of the RHFUQ. Accordingly, the number of disabilities in the study by Thornhill et al. (31) may have been underestimated and the differences between disability figures in their study and ours may be explained by the use of different instruments of assessment (GOS and RFHQ).

Life satisfaction. The total level of life satisfaction on LiSat-11 at follow-up was clearly lower in the CS group than in the CL group of healthy subjects, which is in accordance with the study by Emanuelsson et al. (6). They found scores of quality of life using the instrument SF-36 in patients with MTBI lower in comparison with a gender- and age-matched control group.

Comparison between CS group and non-CS group

Post-concussion symptoms. A greater number of patients in the CS group (70%) compared with the non-CS group (38%) reported post-concussion symptoms one year after the injury. The number of patients experiencing symptoms is in accordance with the percentage documented in previous studies of patients with MTBI (4, 5). The most common symptom in the CS group was headache (reported by 50%), while the corresponding most frequent symptom for the non-CS group was dizziness (reported by 15%). Moreover, headache was also more common in patients in the CS group compared with patients in a previous study of van der Naalt et al. (32) in which one year after trauma headache was present in 23% of their sample of patients.

Disability and life satisfaction. The presence of at least one disability item was reported by most patients in the CS group (94%) and by only 34% in the non-CS group on the RHFUQ at follow-up. The most frequently reported disability items were

"ability to enjoy previous leisure activities"' (81% in the CS group compared with 15% in the non-CS group) and "finding work more tiring" (75% in the CS group compared with 23% in the non-CS group). These findings were further corroborated by the results from LiSat-11, showing that the scores of the items "leisure" and "vocation" were rated lowest by patients in the CS group. Furthermore, the CS group reported a lower total score of LiSat-11 (indicating a lower level of satisfaction) than the non-CS group. Surprisingly, comparisons of rating of the separate items of life satisfaction revealed a difference between the CS group and the non-CS group on the same items as between the CS group and the CL group.

Serum concentrations of S-100B and NSE. No statistically significant difference was found when serum concentrations of S-100B and NSE were compared for the patients in the CS group with the patients in the non-CS group. Furthermore, no association was demonstrated between the number of cognitive deficits in the CS group and serum concentrations of S-100B or NSE. These results are in accordance with recent studies that showed an absence of any significant association between cognitive impairments and the levels of S-100B up to 3 months post-injury (33).

Study limitations

A number of objections may be raised concerning the findings of this study. First, the sample of patients is rather small and the patients were not included consecutively or randomly, which may have biased the results. Secondly, we have no in-depth knowledge of the pre-injury cognitive performance of the patients. Accordingly, we cannot exclude the possibility that the lowered scores for cognitive tests for the CS group are due to the fact that the CS group simply consists of subjects with a low cognitive performance who by chance suffered a head injury. Thirdly, we did not perform formal tests with respect to symptom validity or effort in association with the neuropsychological investigation. Yet, the patients were assessed by a consultant in neuropsychology with great experience of tests of cognitive functioning. Fourthly, it is known that financial compensation issues are reliable correlates of poor outcome after MTBI and we did not thoroughly investigate this area. However, we have good knowledge of the sick-leave situation (7). Only 3 patients out of 69 were on sick-leave at the time of the follow-up because of the MTBI in comparison with the situation on admission to the hospital. It appears therefore that malingering or litigation was not of major importance for the outcome observed at follow-up in our sample of patients.

In conclusion, our study shows that many patients were interested in undergoing the consultation offered at follow-up (16/69, i.e. 23%). The group of consultation-seeking patients exhibited a number of differences when compared with the non-CS patients or the healthy control subjects. The CS group had a higher number of low performances on cognitive tests compared with the control group. Moreover, the CS group showed more disabilities and a lower level of different aspects of life satisfaction compared with both the non-CS group and the CL group. The high frequency of occurrence of disabilities and lower levels of cognitive performance, together with the lower level of life satisfaction, appear to characterize the CS group and may indicate that brain tissue damage might have occurred. This may also reflect an unsatisfied/unmet need for follow-up and rehabilitation after MTBI.

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