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Complicated Mild Traumatic Brain Injury in Older Adults: Post-Concussion Symptoms and Functional Outcome at One Week Post Injury

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Abstract

Primary Objective: Mild Traumatic Brain Injury (MTBI) is commonly categorized as *complicated* when injury severity criteria are mild, but an intracranial abnormality is present on acute neuroimaging. The current study examined whether functional outcomes differed at one-week post injury among older adult patients based on injury severity and acute computed tomography (CT) findings.

Research Design: Participants (≥55 years-old; *n*=173) presenting sequentially to the emergency department with a head injury were divided into three groups: complicated MTBI (positive CT; *n*=22), uncomplicated MTBI (negative CT; *n*=68), and mild head injury (unperformed CT, no documented loss of consciousness or post-traumatic amnesia; *n*=83).

Methods and Procedures: At one-week post injury, the Modified Rankin Scale (i.e., difference score between pre/post-injury ratings; ΔMRS), Glasgow Outcome Scale-Extended (GOS-E), and Rivermead Post-Concussion Symptom Questionnaire (RPQ) were administered.

Main Outcomes and Results: Participants differed on the ΔMRS and GOS-E, but not the RPQ. The complicated MTBI group had worse GOS-E ratings than the uncomplicated MTBI and mild head injury groups and worse ΔMRS than the mild head injury group, but the uncomplicated MTBI and mild head injury groups did not differ on either outcome.

Conclusions: Macrostructural abnormality on CT was associated with worse functional outcome at one-week post MTBI.

Keywords: mild brain injury, neuroimaging, outcome, functional status, post concessional syndrome

Introduction

Mild traumatic brain injuries (MTBI) occur on a broad spectrum, ranging from extremely mild sport-related injuries, from which athletes typically recover within hours or days (1), to high velocity injuries during motor vehicle accidents, approaching the moderate TBI classification range. A complicated MTBI is commonly defined as an injury that appears mild based on all injury severity criteria, including duration of loss of consciousness (LOC), Glasgow Coma Scale (GCS), and duration of post-traumatic amnesia (PTA); but is complicated by the presence of a macroscopic intracranial abnormality identified on day-of-injury neuroimaging (2). Depending on how MTBI is defined, the incidence of acute positive computed tomography (CT) for intracranial lesions varies between 4.7% and 38.9% in individual studies (3,4). Contusions, subarachnoid hemorrhages, and subdural hematomas are the most frequent CT-positive lesions seen in patients with MTBIs (5,6) and only about 1% of these lesions require neurosurgery (7–9). The wide range of intracranial abnormalities is partially explained by varying enrollment of patients with lower GCS scores, because GCS scores below 15 are associated with an increased risk for intracranial injury (10). In one study, the incidence of intracranial abnormalities for patients with GCS scores of 15, 14, and 13 was 10.1%, 36.1%, and 48.1%, respectively (11).

A researcher or clinician might assume, *prima facie*, that those who sustain complicated MTBIs will have substantially worse outcomes than those who do not. The literature relating to complicated MTBI, however, is mixed. Some researchers have reported that patients with complicated MTBIs, as a group, are more likely to have early cognitive deficits (2,12–14) and worse medium (15) and long-term (16) impairments in functional outcome. However, there are studies showing no relationship between the presence of an intracranial abnormality and neuropsychological performances or post-concussion symptoms following MTBI (17–20),

indicating complicated MTBI is an injury of a broad spectrum, from patients having very small abnormalities and excellent functional outcome to patients having poor outcome—and a diverse set of patients in between.

Significant research interest has focused on outcomes from MTBI among younger age groups (21,22), often presenting following motor vehicle accidents or sport-related concussion. In contrast, older adults often present with MTBI due to falls (23), and outcomes from injuries among older adults are not well understood. Much of the research on complicated MTBI specifically has focused on middle-aged adults as opposed to older adults (2,12–20). The incidence of TBI among older adults has increased (24), but there are few to no evidence-based guidelines for the clinical management of older adults following any severity of TBI (25). The absence of guidelines is due, in part, to limited research focus on older adults with TBI in general, despite a clinical need to understand prognosis and rehabilitation needs across the spectrum of TBI severity.

Very few studies have examined outcomes from MTBI among older adults (25), and the existing studies have produced mixed findings. Whereas some research has shown poor neuropsychological (26) and functional (27) outcomes following MTBI among older adults, other studies using an orthopedic injury comparison group have found no effect of MTBI on neuropsychological performances (28,29). Nonetheless, older adults may be at greater risk of poor outcomes following MTBI compared to younger adults, especially those who are hospitalized after injury. After an approximately one-week hospitalization post milder spectrum TBI, about 60-65% of older adults presented with good recovery at discharge; however, more older adults (i.e., 23%) were rated as severely disabled than younger adults (i.e., 9%), and a greater percent of older adults (i.e., 28%) were discharged to rehabilitation settings than younger

adults (i.e., 16%) (30). Among those older adults categorized as having MTBI based on a GCS of 13-15 in this sample, 48% underwent neurosurgical intervention, indicating that many of these participants had more severe brain injuries that did not qualify as mild. Another study found that older adults with milder spectrum TBI tended to have longer hospital stays than younger adults, remaining in the hospital for 15 days on average with worse functional, physical, and cognitive outcomes (31). This sample of older adults represented more severe cases of MTBI, where participants were admitted to a Level I trauma center based on specific injury criteria (e.g., positive CT, skull fracture, PTA $\geq$ 60 minutes, post-traumatic convulsions, accompanying orthopedic injuries).

Relative to more severe forms of TBI, there has been less research examining predictors of functional outcomes following MTBI among older adults (25). Studies suggest older adults are at greater risk of subdural hematomas with increased age (32), and show a higher rate of positive CT scans compared to younger samples following a MTBI (11), which could correspond to worse outcomes (30,31). This study examined whether intracranial abnormalities detected by CT are related to functional outcomes among older adults with MTBI more proximal to the initial injury. The current investigation evaluated differences in one-week outcomes in functional impairment and post-concussion symptoms between older adults with complicated MTBI, uncomplicated MTBI, and mild head injury, hypothesizing that participants with complicated MTBI would have worse outcomes compared to those with uncomplicated MTBI and mild head injury.

Materials and Methods

Participants

The Tampere University Hospital Emergency Department (ED) provides services to a combination of urban and rural municipalities with approximately 470,000 residents, offering the only neurosurgical referral center within its geographical area. At the Tampere University Hospital ED between November 2015 and November 2016, 325 adult patients (age range: 18 to 96) evaluated for head injury consented to enroll in an ongoing prospective study. Participants were removed from analysis if they were between ages 18 and 54 (n=120), had a GCS less than 13 (n=4), had no valid outcome measure (n=18), had neurosurgery or another type of surgery due to the acute injury (n=6), had a new head injury within a week of the initial injury (n=2), or died within a week of the injury (n=2), which resulted in the final sample of 173 participants. The Ethical Committee of Pirkanmaa Hospital District, Finland approved this study (ethical code: R15045). All enrolled patients provided written informed consent according to the Declaration of Helsinki.

TBI signs were gathered by the on-call ED physician along with records from pre-hospital ambulance personnel. GCS was rated in the ED by a physician. Referrals for CT scanning were based on Scandinavian guidelines for the initial management of minimal, mild, and moderate head injuries (33). CT scans were read for research purposes by a radiologist using National Institute of Neurological Disorders and Stroke Common Data Elements (34). Participants were grouped into three categories: (a) complicated MTBI, which included participants with positive CT (n=22, 50.0% women, $\bar{x}_{age}$=79.73 year±10.36 years-old); (b) uncomplicated MTBI, which included participants with negative CT (n=68, 47.1% women, $\bar{x}_{age}$=72.88±10.07 years-old); and (c) mild head injury, which included participants that were not

referred for CT (n=83, 56.6% women, $\bar{x}_{age}$=76.29±10.42 years-old). Groups did not significantly differ in regard to mechanism of injury: 85.0% (n=147) of injuries resulted from a ground-level fall, 9.2% (n=16) of injuries resulted from any other type of fall, and 5.8% (n=10) resulted from another cause (e.g., assault, sport-related, motor vehicle accident).

The rates of LOC and PTA by group are provided in Table 1. LOC was defined as positive based on eyewitness report and suspected based on information gathered from pre-hospital records and/or patient self-report in the absence of an eyewitness account. For the complicated MTBI group, 31.8% had positive or suspected LOC and 54.5% had positive PTA. For the uncomplicated MTBI group, 72.1% had positive or suspected LOC and 55.9% had positive PTA. Patients with either LOC, PTA, or GCS=13-14 were categorized as having MTBI, whereas patients without documented LOC or PTA and GCS=15 were categorized as having mild head injury. A small number of patients with complicated MTBI (n=3) and uncomplicated MTBI (n=5) had GCS=14. All other patients with MTBI had a GCS of 15. These patients with mild head injury are similar to Head Injury Brain Injury Debatable (HIBRID) patients described by previous researchers (35). It is understood that there is considerable variability in how injury severity characteristics, such as LOC and PTA, are documented in the ED, and it is likely that some or even many people who had no documentation of PTA in their ED records might actually have experienced some degree of PTA following their head injury. Among participants with complicated MTBI, the most common lesions on head CT were subdural hematoma (n=11; 50.0%), subarachnoid hemorrhage (n=8; 36.4%), and contusion (n=5; 22.7%). Multiple traumatic lesions were detectable on 22.7% (n=5) of scans. Of note, although these participants were categorized as complicated MTBI in the current study, some operational definitions of TBI (36,37) would categorize these patients as having moderate TBIs based on positive CT.

Certain pre-existing conditions may affect MTBI outcomes in older adults (38) and could affect the outcomes of this study. Participants had their medical records reviewed for preexisting conditions, which were categorized as either present or absent based on the International Classification of Diseases, Tenth Edition (ICD-10) (39). The medical history collected was from the patient records of the Tampere University Hospital and Tampere City systems, which included all health care centers and one local hospital in the city of Tampere. Three categories were constructed based on the pre-existing health information of participants: dementia, neurological disorders, and diseases of the circulatory system. The exact ICD-10 codes included in each of these categories are listed in the footnote of Table 2.

Measures

The Modified Rankin Scale (MRS) (40–42) is a clinician-administered instrument that rates the severity of patient disability from 0 to 6. The possible ratings include no symptoms, symptoms/no disability, slight disability, moderate disability, moderate-severe disability, severe disability, and dead. A higher score indicates greater disability. Participants were rated based on their retrospective report of pre-injury disability severity and their post-injury disability severity. An MRS score of 3 (moderate disability) to 6 (dead) was considered a poor outcome at one week. The difference score between pre-injury and post-injury ratings, hereafter referred to as ΔMRS, was used as the primary outcome for this scale in all analyses.

The Glasgow Outcome Scale-Extended (GOS-E) (43) is another clinician-administered measure where functional outcomes of patients are rated on a scale from 1 to 8, with a higher score indicative of better recovery following injury. The possible ratings include death, vegetative state, lower severe disability, upper severe disability, lower moderate disability, upper

moderate disability, lower good recovery, and upper good recovery. A GOS-E of 1 (death) to 6 (upper moderate disability) was considered a poor outcome.

The Rivermead Post-Concussion Symptoms Questionnaire (RPQ) (44) is a 16-item self-report questionnaire on which participants rate the severity of their post-concussion symptoms (e.g., headaches, sleep disturbance, nausea and/or vomiting). Each item is rated on a 5-point Likert-type scale, including ratings of not experienced at all, no more of a problem, a mild problem, a moderate problem, and a severe problem. Each item was scored from 0 to 4 points and were then summed, with the RPQ total score ranging from 0 to 64. If a patient rated the symptom as not experienced or no more of a problem, the item was scored as a 0. If a patient rated a problem mild, moderate, or severe, the item was scored as 2, 3, or 4, respectively. This scoring is consistent with previously psychometric studies on the RPQ (44,45), and a higher score was indicative of more severe post-concussion symptoms.

Procedure

A dedicated nurse with neurological training administered all measures via phone one-week post injury. Neither the nurse nor the patients were blinded to CT findings at the time the measures were administered. All measures were administered in Finnish. Data were collected in the context of validating guidelines for minimal to moderate head injury management (46), and the one-week follow-up interval was selected to capture acute complications following MTBI or head injury and the relationship between these complications and head CT findings.

Statistical Analyses

The distributions of the ΔMRS, GOS-E, and RPQ were evaluated for normality using the Shapiro-Wilk test for each participant group, with all tests indicating non-normal distributions ($p<.05$). The analyses were run using non-parametric statistics (i.e., Kruskal-Wallis *H* with post

hoc pairwise comparisons using Mann-Whitney *U*). The probability of superior outcome ($\hat{p}_{a.b}$) was calculated as a non-parametric effect size statistic for a pairwise comparison between independent groups, calculated as the *U* statistic divided by the product of the sample sizes for each group (47). This effect size provides the probability that a score randomly drawn from one group would be higher than a score randomly drawn from another group. A one-way ANOVA evaluated if age differed across groups, and the relationship between age and ΔMRS, GOS-E, and RPQ was assessed by calculating Spearman *rho* correlations. A series of X^2 analyses evaluated whether gender representation or the frequencies of dementia, neurological disorders, and diseases of the circulatory system differed between groups. Participants with missing data were excluded using listwise deletion.

Results

Mean age [$F(2, 170)=4.30$, $p=.015$] was significantly different across groups, with the complicated MTBI group being significantly older than the uncomplicated MTBI group ($p=.022$). There were no other differences in age based on pairwise comparisons. The correlation between age and GOS-E was significant ($rho=-.334$, $p<.001$) whereas the correlations between age and ΔMRS ($rho=-0.19$, $p=.803$) and RPQ ($rho=.095$, $p=.299$) were non-significant. Gender representation was not significantly different across groups [$X^2(2)=1.41$, $p=.494$]. The three groups did not have any significant differences in the frequency of pre-injury dementia, circulatory, or other neurological diagnoses, although it is noteworthy that a large minority of those in the mild head injury group had a pre-existing neurological disorder. The results of X^2 analyses and the frequency of each diagnostic category across groups is presented in Table 2.

The median and interquartile range (IQR) for the ΔMRS, GOS-E, and RPQ for each participant group and the total sample, along with the results of all analyses, are summarized in

Table 3. Kruskal-Wallis *H* tests revealed significant differences between groups for the ΔMRS and the GOS-E, but not the RPQ. Post hoc comparisons indicated significantly worse GOS-E scores in those with complicated MTBI versus uncomplicated MTBI (U=468, p=.007, $\hat{p}_{a.b}$=0.43), but no differences in the ΔMRS. There were significant differences between the complicated MTBI and mild head injury groups for the GOS-E (U=614, p=.015, $\hat{p}_{a.b}$=0.46) and the ΔMRS (U=646, p=.014, $\hat{p}_{a.b}$=0.35). The uncomplicated MTBI and mild head injury groups did not significantly differ on any outcome. An additional post hoc analysis examined pre-injury and post-injury MRS ratings. Per a Kruskal-Wallis *H* test, the participant groups differed on post-injury [$X^2(2)$=6.02, p=.049], but not pre-injury MRS ratings [$X^2(2)$=3.44, p=.179].

The frequency of ratings on the MRS (both pre-injury and post-injury) and GOS-E for each participant group and the total sample are provided in Tables 4 and 5, respectively. The frequency of one-week poor outcome (MRS=3-6 or GOS-E=1-6) was 77.3 to 81.8% for the complicated MTBI group, 50.0 to 70.6% for the uncomplicated MTBI group, and 55.4 to 78.3% for the mild head injury group. For the total sample, 75.7% of older adults had a poor outcome on the MRS (Table 4) and 56.1% had a poor outcome on the GOS-E (Table 5) at one-week after sustaining a mild head injury or MTBI. It is important to note that 63.0% of older adults were rated as having poor functioning *before* their MTBI on the MRS. For each item on the RPQ, the percentage of the sample endorsing the symptom as mild or greater in severity are provided in Table 6 for each group and the total sample. The most commonly reported symptoms on the RPQ at one-week post MTBI were fatigue (34.7%), headache (23.4%), dizziness (21.8%), sleep disturbance (18.5%), and blurred vision (10.5%).

Discussion

Older adults with complicated MTBIs had worse clinical outcomes at one-week compared to those with uncomplicated MTBIs and mild head injuries based on functional measures (i.e., ΔMRS and GOS-E), but not based on symptom reporting (i.e., the RPQ). These results indicate that the presence of a macrostructural abnormality on a CT scan was associated with worse functional outcome, while the presence of clinical signs of injury (e.g., LOC, PTA) in the absence of CT findings was not associated with worse functional outcome. Further, group differences were observed for clinician ratings of functional ability, but not post-concussion symptom reporting by participants. In turn, despite participants in different groups reporting similar symptom severity, clinicians documented greater functional impairment among older adults following complicated MTBI compared to uncomplicated injuries.

The findings show differences in functional outcome post injury; however, they also indicated a high rate of preexisting functional impairment among participants, likely attributable to the preexisting medical conditions. Per retrospective ratings on the MRS, 63.0% of the total sample was functionally impaired prior to their recent MTBI with a slight to moderate-severe disability. Few past studies on TBI among older adults have involved pre-injury ratings of functional status (25), which are likely related to outcomes following injury. Pre-existing dementia, neurological, and circulatory disorders were quite common across groups. In the total sample, 16.9% of participants had dementia, 32.7% had neurological disorders, and 82.7% had circulatory diseases. These conditions have either a definite or potential impact on independent functioning, and self-rated poor health prior to MTBI has been related to poor recovery at six months post injury (38).

In addition to the influence of preexisting conditions, participants also differed based on age, with the complicated MTBI group roughly seven years older than the uncomplicated MTBI group on average. This finding is consistent with previous results suggesting a higher risk of acute intracranial abnormalities following MTBI with older age (11). Age also correlated with GOS-E, which was the only outcome that significantly differed between the complicated and uncomplicated MTBI groups, and the observed differences between groups may be attributable, at least in part, to age. However, these groups did not significantly differ in pre-injury functioning on the MRS or rates of pre-existing conditions that could impact functional status. Further research is needed to understand the relationship between age, acute intracranial abnormalities, and outcome among older adults.

The study has additional limitations that may have affected the findings and the inferences that can be drawn from the findings. This study only examined patients at one-week post injury, and the relationship between abnormal acute CT findings and functional outcome beyond one week following MTBI in older adults remains unknown. The study involved a sample of patients from a single ED with GCS rated at the ED by the physician. Some patients may have had lower GCS at the time of their initial injury, but data on GCS prior to arriving at the ED was not available. and because data collection was conducted through emergency care, patients were referred for head CT based on clinical guidelines (48), which led to many patients without imaging data. Those patients without clinical signs of injury who did not undergo CT were included in the mild head injury group, and some may have had unobserved intracranial abnormalities. Because CT scans were conducted in the context of clinical care, neither the patient nor the clinician were blinded to CT findings prior to rating impairment or symptom severity. In terms of the instruments used as outcomes, previous researchers have criticized the

use of broad scales of disability, such as the GOS-E, among older adults, because they were not developed or validated for use within this age group (25). They may lack the sensitivity to accurately detect subtle differences between the mild head injury and uncomplicated MTBI groups.

This study examined the value of CT for predicting acute functional outcomes following MTBI among older adults. At the milder end of TBI severity, GCS is less informative at predicting individual differences in outcome. Most patients in the current study presented with a maximum GCS of 15, and CT findings may have added prognostic value in contexts where GCS does not differentiate between patients. The current findings may better inform clinicians regarding the likely level of care required during acute hospitalization, and the potential for rehabilitation needs following discharge. The utility of CT findings in the assessment of older adults has been supported by previous research examining cognitive outcomes one to two months post injury, where older adults with complicated MTBI had worse performances on tests of language and executive function compared to older adults without intracranial pathology (49). Another past study examined prospective memory following complicated MTBI in older adults (29), identifying acute intracranial abnormalities as the only injury-related variable to predict cognitive performance at three-months post injury. Although neuropsychological testing was not used in the current study, previous research on older adults has shown both no effects (50), and adverse effects (49,51), of MTBI on cognitive functioning at various time points post injury. Many neuropsychological tests offer older adult norms and a greater range of possible scores, and they may detect group differences that could be missed when using gross ratings of functional outcome.

Further research is necessary to understand the variables related to poor recovery following MTBI among older adults. Researchers have found that fairly large portions of older adults with MTBI present with some level of functional impairment or rehabilitation needs in weeks to months post injury (27,30,31,38). A rich body of research has examined predictors of recovery following concussion (52), but this research has focused almost exclusively on younger populations. Future investigations could integrate both cognitive and functional assessment when evaluating MTBI outcomes among older adults, determining the added utility of cognitive evaluations in combination with imaging and neurobehavioral evaluations when predicting recovery among older patients.

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Table 1. Rates of Loss of Consciousness and Post-Traumatic Amnesia by Participant Group

	LOC								PTA						LOC/PTA							
	Yes		Suspected		No		Unknown		Yes		No		Unknown		LOC+/ PTA+		LOC+/ PTA-		LOC-/ PTA+		LOC-/ PTA-	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Complicated MTBI (*n*=22)	3	13.6	4	18.2	8	36.4	7	31.8	12	54.5	5	22.7	5	22.7	6	27.3	1	4.5	6	27.3	9	40.9
Uncomplicated MTBI (*n*=68)	11	16.2	38	55.9	11	16.2	8	11.8	38	55.9	26	38.2	4	5.9	22	32.4	27	39.7	16	23.5	3	4.4
Mild Head Injury (*n*=83)	0	0	0	0	69	83.1	14	16.9	0	0	76	91.6	7	8.4	0	0	0	0	0	0	83	100
Total (*n*=173)	14	8.1	42	24.3	88	50.9	29	16.8	50	28.9	107	61.8	16	9.2	28	16.2	28	16.2	22	12.7	95	54.9

Note. LOC=Loss of consciousness, PTA=Post-traumatic amnesia, LOC+/PTA+=LOC Positive or Suspected and PTA Positive, LOC+/PTA-=LOC Positive or Suspected and PTA Negative or Unknown, LOC-/PTA+=LOC Negative or Unknown and PTA Positive, LOC-/PTA-=LOC Negative or Unknown and PTA Negative or Unknown; Positive loss of consciousness was eyewitnessed.

Table 2. Frequencies of Diagnoses across MTBI Groups

Diagnostic Category	X^2 (*df*), *p*	Percent with Diagnosis			
		Complicated MTBI (*n*=22)	Uncomplicated MTBI (*n*=68)	Mild Head Injury (*n*=83)	Total Sample (*N*=173)
Dementia	$X^2(2)=1.19$, $p=.552$	22.7%	13.4%	18.1%	16.9%
Neurological Disorder	$X^2(2)=4.05$, $p=.132$	27.3%	25.4%	40.2%	32.7%
Circulatory Disease	$X^2(2)=1.27$, $p=.531$	90.9%	82.4%	80.7%	82.7%

Note. Dementia included Alzheimer's disease (G30), vascular dementia (F01), and unspecified dementia (F03). Circulatory diseases included diseases of the circulatory system (I00-99; e.g., hypertensive disease, ischemic heart disease, pulmonary heart disease, cerebrovascular diseases, etc.). Neurological disorders included inflammatory diseases of the central nervous system (G00-09), extrapyramidal movement disorder (G20-26), other degenerative diseases of the nervous system (G30-32), demyelinating diseases of the central nervous system (G35-37), transient cerebral ischemic attacks and related syndromes (G45), nerve, nerve root and plexus disorders (G50-59), polyneuropathies and other disorders of the peripheral nervous system (G60-64), diseases of the myoneural junction and muscle (G70-73), cerebral palsy and other paralytic syndromes (G80-83), other disorders of the nervous system (G90-99), malignant neoplasm of meninges (C70), malignant neoplasm of brain (C71), benign neoplasm of meninges (D32), benign neoplasm of brain and other parts of central nervous system (D33), neoplasm of uncertain or unknown behavior of meninges (D42), neoplasm of uncertain or unknown behavior of brain and central nervous system (D43). MTBI = Mild Traumatic Brain Injury.

Table 3. Means and Standard Deviations for ΔMRS, GOS-E, and RPQ by Group

	Kruskal-Wallis *H* Test			Complicated MTBI			Uncomplicated MTBI			Mild Head Injury			Total		
	X^2	*df*	*p*	*n*	*Mdn*	*IQR*	*n*	*Mdn*	*IQR*	*n*	*Mdn*	*IQR*	*N*	*Mdn*	*IQR*
ΔMRS	6.15	2	.046	22	1[b]	0-2	68	0	0-1	83	0[b]	0-1	173	0	0-1
GOS-E	7.75	2	.021	22	4[a,b]	3-6	68	7[a]	4-8	83	4[b]	4-8	173	5	4-7
RPQ	2.86	2	.239	12	4	0-7	49	2	0-6	61	0	0-4	122	2	0-6

Note. [a]Indicates significant difference ($p<.05$) based on post hoc Mann-Whitney *U* test between Complicated and Uncomplicated MTBI groups. [b]Indicates significant difference ($p<.05$) based on post hoc Mann-Whitney *U* test between Complicated MTBI and Mild Head Injury groups. ΔMRS = Modified Rankin Scale Post-Injury versus Pre-Injury Difference Score; MTBI = Mild Traumatic Brain Injury; GOS-E = Glasgow Outcome Scale – Extended; IQR = Interquartile Range; RPQ = Rivermead Post-Concussion Symptoms Questionnaire total score.

Table 4. Pre-injury and Post-Injury MRS Ratings by Group

	Complicated MTBI		Uncomplicated MTBI		Mild Head Injury		Total	
	n	%	*n*	%	*n*	%	*N*	%
Pre-Injury (Retrospectively rated)								
0, No Symptoms	5	22.7	24	35.3	18	21.7	47	27.2
1, Symptoms, No Disability	3	13.6	6	8.8	8	9.6	17	9.8
2, Slight Disability	6	27.3	20	29.4	27	32.5	53	30.6
3, Moderate Disability	7	31.8	15	22.1	24	28.9	46	26.6
4, Moderate-Severe Disability	1	4.5	3	4.4	6	7.2	10	5.8
5, Severe Disability	0	0	0	0	0	0	0	0
6, Dead	0	0	0	0	0	0	0	0
Post-Injury								
0, No Symptoms	2	9.1	6	8.8	10	12.0	18	10.4
1, Symptoms, No Disability	2	9.1	14	20.6	8	9.6	24	13.9
2, Slight Disability	3	13.6	21	30.9	23	27.7	47	27.2
3, Moderate Disability	8	36.4	19	27.9	30	36.1	57	32.9
4, Moderate-Severe Disability	3	13.6	8	11.8	10	12.0	21	12.1
5, Severe Disability	4	18.2	0	0	2	2.4	6	3.5
6, Dead	0	0	0	0	0	0	0	0

Note. MRS = Modified Rankin Scale; MTBI = Mild Traumatic Brain Injury.

Table 5. Post-injury GOS-E Ratings by Group

	Complicated MTBI		Uncomplicated MTBI		Mild Head Injury		Total	
	n	%	*n*	%	*n*	%	*N*	%
1, Death	0	0	0	0	0	0	0	0
2, Vegetative state	2	9.1	0	0	2	2.4	4	2.3
3, Lower severe disability	8	36.4	12	17.6	11	13.3	31	17.9
4, Upper severe disability	5	22.7	15	22.1	29	34.9	49	28.3
5, Lower moderate disability	0	0	3	4.4	1	1.2	4	2.3
6, Upper moderate disability	2	9.1	4	5.9	3	3.6	9	5.2
7, Lower good recovery	2	9.1	15	22.1	16	19.3	33	19.1
8, Upper good recovery	3	13.6	19	27.9	21	25.3	43	24.9

Note. MTBI = Mild Traumatic Brain Injury; GOS-E = Glasgow Outcome Scale – Extended.

Table 6. Percent Endorsing RPQ Items by Injury Group

	Complicated MTBI (*n*=12)		Uncomplicated MTBI (*n*=68)		Mild Head Injury (*n*=83)		Total (*N*=122)	
	n	*% ≥ 2*	*n*	*% ≥ 2*	*n*	*% ≥ 2*	*n*	*% ≥ 2*
Headaches	6	50.0	13	25.5	10	16.4	29	23.4
Feelings of dizziness	3	25.0	13	25.5	11	18.0	27	21.8
Nausea and/or vomiting	1	8.3	4	7.8	3	4.9	8	6.5
Noise sensitivity, easily upset by loud noise	1	8.3	2	3.9	1	1.6	4	3.2
Sleep disturbance	2	16.7	11	21.6	10	16.4	23	18.5
Fatigue, tiring more easily	6	50.0	20	39.2	17	27.9	43	34.7
Being irritable, easily angered	0	0	3	5.9	2	3.3	5	4.0
Feeling depressed or tearful	1	8.3	5	9.8	4	6.6	10	8.1
Feeling frustrated or impatient	0	0	5	9.8	3	4.9	8	6.5
Forgetfulness, poor memory	3	25.0	6	11.8	3	4.9	12	9.7
Poor concentration	1	8.3	5	10.0	6	9.8	12	9.8
Taking longer to think	2	16.7	4	8.0	3	4.9	9	7.3
Blurred Vision	1	8.3	7	13.7	5	8.2	13	10.5
Light sensitivity, easily upset by bright light	0	0	5	9.8	2	3.3	7	5.6
Double Vision	0	0	0	0	0	0	0	0
Restlessness	0	0	3	6.0	4	6.6	7	5.7

Note. % ≥ 2 = The percent of participants rating a symptom of mild (i.e., 2 points) or greater severity; MTBI = Mild Traumatic Brain Injury; RPQ = Rivermead Post-Concussion Symptoms Questionnaire. Comparing their current symptoms to before their injury, each RPQ item is rated on the following Likert-type scale: Not experienced at all (0), no more of a problem (1), a mild problem (2), a moderate problem (3), and a severe problem (4), with ratings of 0 and 1 both scored as 0.