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RECOVERY OVER SIX-MONTHS OF MEDICAL DECISION MAKING CAPACITY FOLLOWING TRAUMATIC BRAIN INJURY

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Abstract

Objective—To investigate recovery of medical decision-making capacity (MDC) over six-months in persons with traumatic brain injury (TBI) stratified by injury severity.

Design—Longitudinal study comparing controls and TBI patients one month after injury (T1) and six-months after injury (T2).

Setting—Inpatient TBI rehabilitation unit and outpatient neurology department.

Participants—60 controls and 91 patients with TBI stratified by injury severity: 27 mild (mTBI), 20 complicated mild (cmTBI), and 44 moderate/severe (msevTBI).

Interventions—Not applicable.

Main Outcome Measures—We used the Capacity to Consent to Treatment Instrument (CCTI) to evaluate MDC performance on five consent standards (expressing choice, reasonable choice, appreciation, reasoning, and *understanding*). We also assigned capacity impairment ratings on the consent standards to each TBI participant using cut-scores referenced to control performance.

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Statistical analyses were performed by Dr. Triebel and Dr. Kennedy, UAB, Birmingham, AL.

Results—Control performance was stable across time on the consent standards. Patients with mTBI and cmTBI performed below controls on the *understanding* standard at T1 but not T2. Patients with msevTBI performed below controls on *appreciation*, *reasoning*, and *understanding* at T1 and on *appreciation* and *understanding* at T2, but showed substantial improvement over time.

Conclusions—Regardless of injury severity, all groups with TBI demonstrated baseline impairment of MDC with subsequent partial or full recovery of MDC over a six-month period. However, a sizeable proportion of individual TBI patients in each group continued to demonstrate capacity compromise at six-months post-injury. Clinically this finding suggests that individuals with TBI, regardless of injury severity, need continued monitoring regarding MDC for at least six-months after injury.

Keywords

Brain Injuries; Informed Consent; Decision Making; Ethics; Medical

Medical decision making capacity (MDC), also known as treatment consent capacity, is a key clinical issue for persons with traumatic brain injury (TBI) and their families, and for physicians who treat them. MDC refers to a person's cognitive and emotional ability to accept or refuse a proposed treatment, or to select among treatment alternatives^{1,2}. Persons with traumatic brain injuries can experience a range of cognitive impairments that may impair their ability to make treatment decisions including whether to have orthopedic surgery, rehabilitation, and psychiatric treatment^{3, 4}. Rehabilitation and other clinicians need guidance regarding the effects of TBI injury severity on initial impairment of MDC and on expected recovery of such abilities over time. Such information is important for planning purposes, for making clinical recommendations, and for knowing when intervention might be beneficial.

Our group has previously investigated MDC longitudinally in a small TBI sample with moderate to severe injury⁴. This earlier study found that the majority of this group had impaired MDC at one-month after TBI with partial recovery by six-months. In addition, a cross-sectional study recently showed that MDC was largely intact in patients with uncomplicated mild TBI but was impaired in patients with complicated mild TBI⁵. However, there are no longitudinal studies of MDC in milder forms of TBI. As such patients represent the majority of TBI cases, the lack of MDC research in mild TBI represents an important gap in the TBI literature.

The present study longitudinally investigated MDC over six-months in persons representing a spectrum of TBI severity: uncomplicated mild TBI (mTBI), complicated mild TBI (cmTBI), and moderate/severe TBI (msevTBI). Based on prior cross-sectional research, we hypothesized that the cmTBI and msevTBI groups would demonstrate impaired MDC at baseline (one month post-injury). We also hypothesized that six-months post-injury, persons in all three TBI groups would show significant improvements in performance from baseline on the treatment consent standards of *appreciation*, *reasoning*, and *understanding*. We further hypothesized that six-months after injury, persons with mTBI would not differ significantly from healthy controls on *appreciation*, *reasoning*, and *understanding*, but that

persons with cmTBI would continue to show some MDC impairment. Finally, we hypothesized that patients with msevTBI at six-months would show improvement but continue to be impaired relative to controls on the three consent standards.

METHODS

Participants

Healthy adult controls and persons with subacute TBI (within 30 days of injury) were prospectively enrolled between October 2007 and December 2011 as part of a NIH funded longitudinal study investigating medical decision-making capacity following TBI (Recovery of Lost Abilities in Medical Decision-Making Study) (“RECLAIMED Study”). Of the 112 persons with TBI in RECLAIMED, 21 were excluded (non-completers) resulting in 91 persons with TBI for this paper. Of the 21 non-completers in the TBI sample, 2 were excluded at baseline (non-completers) due to self-reported poor test effort. Nineteen were missing 6-month data due to the following: scheduling problems (n=1), not interested in participating (n=3), too ill (n=1), no shows (n=5), distance (n=1), skipped visit due to being outside of window for follow-up (n=1), and unknown (n=7). Persons with TBI were recruited through the Emergency Department, Neurosurgery inpatient service, and Spain Rehabilitation Center at the School of Medicine, University of Alabama at Birmingham (UAB). Mean time from date of brain injury to date of initial study evaluation was 32.4 days (12.2SD). Participants were also assessed six-months after injury with a two-week scheduling window on either side. All TBI participants were assigned a study diagnosis and injury severity level by a board-certified rehabilitation neuropsychologist (TAN) using diagnostic criteria from TBI Model Systems⁶. These criteria define TBI as damage to brain tissue caused by an external mechanical force as evidenced by: loss of consciousness due to brain trauma, posttraumatic amnesia (PTA), or objective neurological findings reasonably attributed to TBI on physical or mental status examination⁷. All study participants had closed head injuries; individuals with penetrating brain injuries (e.g., gun-shot wound) were excluded. Table 1 lists the causes of injury for the TBI sample.

Mild TBI (mTBI) was characterized by one or more of the following criteria: 1) initial Glasgow Coma Scale (GCS) score ≥ 13 ⁸, 2) PTA, if extant, ≤ 24 hours, and/or 3) any loss of consciousness ≤ 30 minutes. In addition, mTBI patients had no evidence of structural brain changes on CT scans.

Complicated mild TBI (cmTBI) was characterized like mTBI except that participants also had evidence of structural brain changes (such as contusions, subdural hematoma, or diffuse axonal injury) on cranial MRI or CT scan⁹.

Moderate/severe TBI (msevTBI) was characterized by one or more of the following criteria: 1) initial GCS score ≤ 12 ^{10,11} and/or 2) PTA >24 hours^{8,12,13}, and (3) evidence of structural brain changes on cranial MRI or CT scan. Initial GCS scores were not available for intubated msevTBI patients.

Patients were excluded if they had received substance abuse treatment within one-year from enrollment (per patient/family report) or had a pre-existing CNS neurological diagnosis

(including prior mTBI), developmental disorder, or severe psychiatric disorder. Individuals with a prior mTBI were included if their prior injury occurred at least one-year before enrollment.

Of 66 controls recruited through local advertisements, 6 were lost to follow-up (non-completers) resulting in 60 controls. Reasons for control attrition included the following: employment (n=1), no show (n=1), self-reported poor effort (n=1), illegal drug use disclosed after enrollment (n=1), and unknown (n=2). Controls were selected to match TBI participants on demographic variables of age, gender, ethnicity, and education. Controls were without diseases/conditions that could potentially affect cognition, including psychiatric disorder (except mild depression), substance abuse, cerebrovascular disease, or other neurologic diseases. None of the controls were taking medications known to affect cognition.

Procedures

All participants completed the study's consent capacity measure and a comprehensive battery of neuropsychological and psychological measures. Results from the neuropsychological test battery will be reported in a separate paper.

Written informed consent was obtained from each participant or in some cases their legal representative or a family member. The study procedures followed protocol and accord with the ethical standards of the UAB institutional review board, which approved this study.

Measures

Consent Capacity Measure—Treatment consent capacity was assessed using the Capacity to Consent to Treatment Instrument (CCTI)¹⁴, a conceptually based, reliable and valid psychometric instrument for assessing MDC in both healthy and cognitively-impaired adults^{14,15}. The CCTI comprises two clinical vignettes that each present a hypothetical medical problem (A: neoplasm and B: cardiovascular disease) and symptoms, and two treatment alternatives with associated risks and benefits. Participants answer standardized questions designed to assess each of the following four core consent standards (Ss) derived from legal and medical literature^{14,16}:

S1: expressing a treatment choice (*expressing choice*);

S3: appreciating the personal consequences of a treatment choice (*appreciation*);

S4: providing rational reasons for a treatment choice (*reasoning*); and

S5: understanding the treatment situation, available treatment choices, and respective risks/benefits of the treatment choices (*understanding*).

A fifth standard [S2] measures the ability to make a reasonable treatment choice¹⁴. [S2] is not a clinically accepted consent standard because of concerns about the potential arbitrariness of the operative term “reasonable.” Therefore, we treat [S2] (*reasonable choice*) as experimental and use brackets to distinguish it from the other standards.

The two CCTI vignettes were administered to participants by simultaneously presenting both oral and written information to all participants. After vignette presentation, the written

format was removed and participants responded to oral questions examining each CCTI standard. CCTI administration and scoring were performed by trained research assistants according to well-operationalized criteria¹⁴. Each participant's responses to the CCTI questions were audio-taped and transcribed to ensure scoring accuracy. Research assistants who scored the protocols were blinded to participants' group status; the study investigators were not involved in either CCTI administration or scoring.

Data Analysis

Demographic variables were analyzed using one-way ANOVA (age, years of education, GCS score, Galveston Orientation and Amnesia Test [GOAT] score¹⁷) or χ^2 tests/Fisher's exact tests (gender, race). Baseline (T1) and six-month (T2) group comparisons on the CCTI consent standards were performed using one-way ANOVA (S3-S5), Kruskal-Wallis (S1), or χ^2 tests ([S2]). Subsequent post hoc tests for between group differences were conducted using Mann-Whitney U test (S1), pairwise χ^2 tests ([S2]), or Games-Howell tests (S3-S5). For S3-S5, change over time was analyzed using repeated-measures ANOVA to measure between group differences and paired *t* tests to measure within group differences. For S1 and [S2], change over time was analyzed using Friedman's test with follow-up Wilcoxon (S1) tests. All significant omnibus analyses were followed-up with Games-Howell (S3-S5) or Wilcoxon (S1 and [S2]) post hoc tests with Holm's adjustment for multiple comparisons. The significance level for all analyses was $p < .05$. All statistical analyses were performed using SPSS 13.0¹⁸. Additional analyses were conducted to compare completers versus non-completers on baseline variables (demographics, CCTI performance, and injury severity for TBI patients) separately for controls and patients with TBI using Mann-Whitney U tests or χ^2 tests.

We also examined capacity impairment ratings (no impairment, mild/moderate impairment, or severe impairment) for each TBI participant using psychometric cut scores derived from our control group performance. For S3-S5, a "no impairment" rating was defined as a score no more than $<1.5SD$ below the control mean on that standard; a "mild/moderate impairment" rating as a score $>1.5SD$ but $\leq 2.5SD$ below the control mean; and a "severe impairment" rating as a score $>2.5SD$ below the control mean. For (S1), a "no impairment" rating was defined as a score of 4; "mild/moderate impairment" rating as a score of 3, and a "severe impairment" rating as a score of ≤ 2 . For [S2], the only two possible impairment ratings were no impairment (1) and impairment (0).

Assignment of psychometrically-derived impairment ratings is useful in categorizing level of decisional impairment and has been used successfully in previous capacity studies^{14,19,20}. While these impairment ratings have scientific and clinical value, they are used experimentally for scientific purposes and are not representative of participants' actual legal or clinical competency status.

RESULTS

Demographic and Sample Characteristics

Table 1 lists the causes of TBI for the patient sample. Table 2 presents demographic variables for all participants and injury severity data for TBI participants. Groups did not differ in age or education, but differed in gender (greater proportion of males in the msevTBI group) and race (greater proportion of African-Americans in the mTBI group). The msevTBI group had lower GCS and GOAT scores than both the mTBI and cmTBI groups.

We conducted additional analyses examining differences between completers and non-completers separately for controls and TBI participants. For the TBI participants, there were no differences between completers and non-completers in terms of age, education, gender, race, and baseline CCTI performance (all p 's > .05). However, a significantly greater proportion of participants in the msevTBI group ($n=17$, 27.9%) were non-completers compared to the mTBI ($n=1$, 3.6%) and cmTBI ($n=3$, 13.0%) groups ($\chi^2=8.06$, $df=2$, $p=.018$). However, there was not a significant difference between msevTBI completers and msevTBI non-completers on the CCTI standards at baseline (p 's > .05). For controls, there were no differences between completers and non-completers on any demographic or CCTI variables at baseline (all p 's > .05).

Analyses were run with and without covariates for race and gender. Inclusion of these covariates did not change the results, so for brevity we only report results from the unadjusted analyses.

Group Differences on the CCTI Consent Standards at Baseline (T1)

All three TBI groups showed MDC impairment at baseline relative to controls (Table 3). Groups did not differ on *expressing choice* (S1) or *reasonable choice* [S2] at T1 after correcting for multiple comparisons. Regarding *appreciation* (S3), control, mTBI, and cmTBI groups performed better than the msevTBI group. Regarding *reasoning* (S4), the control and mTBI groups performed better than the msevTBI group. Regarding *understanding* (S5), controls performed better than the mTBI, cmTBI, and msevTBI groups, and the mTBI and cmTBI groups performed better than the msevTBI group.

Group Differences on the CCTI Consent Standards at Six-month Follow-up (T2)

At six-months control and TBI groups did not differ on *evidencing choice*, *reasonable choice*, or *reasoning* at T2 after correcting for multiple comparisons. The mTBI and cmTBI groups performed equivalently with controls on all standards at T2 (Table 3). On *appreciation*, controls continued to perform better than the msevTBI group. On *understanding*, control and mTBI groups performed better than the msevTBI group.

Changes Over Time on the CCTI Consent Standards across Groups

Controls were stable over time on all standards (Table 3). In the TBI groups, there were significant group x time interactions on *expressing choice*, *appreciation*, *reasoning*, and *understanding*. On *expressing choice* (S1), there was a significant group x time interaction

due to improvement in the msevTBI group. On *reasonable choice* [S2], there was not a significant interaction but the msevTBI group improved over six-months.

On *appreciation* (S3), analyses revealed significant within group improvement in the msevTBI group ($p=.001$) but stable performance in the control, mTBI, and cmTBI groups. On *reasoning* (S4), the msevTBI group improved over the six-month recovery period ($p<.001$), while control, mTBI, and cmTBI groups remained stable.

On *understanding* (S5) the mTBI ($p=.011$), cmTBI ($p=.025$), and msevTBI ($p<.001$) groups all showed improvement, with the greatest amount of improvement occurring in msevTBI. Controls remained stable on this standard over time.

Capacity Impairment Ratings

Table 4 presents individual capacity impairment ratings (intact, mild/moderate impairment, severe impairment) by TBI subgroup across the five CCTI consent standards at baseline and at six-month follow-up. At baseline, mTBI participants showed high proportions of *intact* ratings across S1, [S2], and S4 ($>85\%$), but a third of mTBI participants had impaired ratings (mild/moderate or severe) for S3 and S5. Although ratings for mTBI had improved at six-months, about 20% of mTBI participants remained impaired on S3 and S5.

For cmTBI patients, at baseline the majority had intact ratings for simple standards of S1 and [S2] (90%) with lower proportions of intact ratings on S3 (70%), S4 (65%), and S5 (55%). At six-months, the cmTBI group demonstrated improved ratings on S4 (85% intact) and S5 (75% intact). Ratings on S3 for the cmTBI group remained stable over six-months.

The msevTBI group had the lowest proportions of intact ratings at baseline for the three complex standards (41% for S3 and S4, 16% for S5). In addition, 6 (14%) participants with msevTBI had impaired ratings for S1 and [S2] at baseline, but all participants with msevTBI had intact ratings for these standards at six-months. The msevTBI group also showed improvement on S3-S5 with intact ratings of 57% on S3, 66% on S4, and 48% on S5 at six-months. However, despite this improvement about 50% of the msevTBI group continued to have impaired capacity ratings on the three complex standards at six-months.

DISCUSSION

The present longitudinal study used standardized clinical vignettes to investigate MDC over a six-month period in persons with a range of TBI severity including milder forms of TBI. Our study findings demonstrate that a substantial portion of all three TBI groups (mTBI, cmTBI, and msevTBI) had impaired MDC one-month following injury. All three TBI groups showed significant improvement in MDC over six-months with fuller recovery in the mTBI and cmTBI groups. However, a sizeable portion of individuals in each group continued to have impaired capacity at six-months.

Controls

Control performance remained stable on all consent standards across the six-month period. This finding suggests that the CCTI performs reliably over time.

Mild TBI

The mTBI patients were impaired relative to controls on the *understanding* standard at baseline (one-month post-injury). This group difference was not significant in our previous study investigating MDC in patients with TBI and controls at one-month post-injury⁵. The current study's larger control group likely resulted in greater power to detect a significant difference between the control and mTBI groups on *understanding*. Our current findings suggest that consent impairments occurring in mTBI within a month of injury relate to more subtle forms of comprehension difficulty and may go undetected unless tested on the factually most challenging consent standard (*understanding*). This is consistent with the mTBI literature which indicates that cognitive impairments in mTBI may only become apparent when there is greater cognitive challenge^{21,22}.

As hypothesized, at six-month follow-up, the mTBI group performed similarly to controls on all of the consent standards. Therefore, consent capacity has returned to normal levels for most patients with uncomplicated mild TBI. The broader neuropsychological literature on cognitive recovery in mTBI supports this finding, which has shown that mTBI patients as a group perform equivalently with controls on most cognitive testing within 3-6 months after injury²³⁻²⁷. Nonetheless, our categorical impairment ratings revealed individual variability in MDC recovery over the six-month period. Approximately 20% of the mTBI group demonstrated capacity compromise (combined mild/moderate and severe impairment ratings) on *understanding* and *appreciation* at six-months. Thus, a small subset of individuals with mTBI continue to experience impaired consent capacity six-months after their injury, reflecting individual differences in recovery even in mTBI. These individual differences would be otherwise obscured by group mean data. Multiple studies have shown similar individual heterogeneity in recovery of cognitive functioning over time in mTBI, with a portion of patients demonstrating cognitive impairments a month or longer post-injury^{22,28,29}. Such persisting impairment may relate to a number of factors, including age, education, gender, medical issues, premorbid psychiatric status, substance abuse history, and premorbid cognitive status³⁰⁻³².

Complicated Mild TBI

The current findings also contribute to the existing literature on cmTBI. At baseline, the cmTBI group performed below controls on *understanding*, confirming the findings from our earlier cross-sectional study⁵. While this study was not powered to detect statistically significant differences between mTBI and cmTBI groups, the capacity impairment rating differences suggest a greater percentage of individuals with impaired MDC in cmTBI versus mTBI at baseline, with both groups converging at six-months. Decisional capacity remained impaired on the *understanding* standard for about 25% of cmTBI patients at six-months.

Moderate/Severe TBI

Consistent with our prior study results^{1,5}, the msevTBI group demonstrated the most severe MDC impairments at baseline. As hypothesized, the msevTBI group also showed considerable improvement in consent capacity over six-months. However, half of participants remained impaired on *appreciation* and *understanding*, and a third remained

impaired on *reasoning* at six-months. These findings confirm the results from our earlier longitudinal study with a separate, larger mTBI group⁴.

Study Limitations and Future Directions—There were limitations to the study. First, our study was not powered to detect differences between the mTBI and cmTBI groups. Second, the impairment ratings were used experimentally for scientific purposes and were not intended to represent participants' actual legal or clinical competency status. Third, individuals may respond differently to hypothetical vignettes than to real-life, personal medical situations. For example, real-life medical problems may trigger emotional aspects of MDC not captured by hypothetical vignettes.

In terms of future directions, cross-validation of study findings in other mTBI, cmTBI, and mTBI samples in a variety of locations and settings would further establish external validity of the study findings. Second, studies examining MDC in this population over a longer period of observation would provide useful information about long-term outcomes. Third, studies examining clinical predictors of MDC change over time are needed to identify reasons for improvement (or lack of improvement) in patients with TBI.

Conclusions—First, consistent with our hypotheses and the TBI literature, a proportion of TBI patients across all injury levels show impaired MDC one month after injury and then demonstrate partial or full MDC recovery over six-months. MDC improvement and outcome appear to depend on injury severity. The greatest amount of improvement occurred in patients with mTBI, perhaps because they have greater room to improve given their lower baseline performances. However, at the same time, the mTBI group had the worst longitudinal outcome as they remained impaired on *appreciation*, *reasoning*, and *understanding* standards relative to controls at six-months. Finally, a sizeable minority of individuals with mTBI and cmTBI (approximately 20% and 25%, respectively) still demonstrate deficits in consent capacity six-months post-injury. Clinically, the current findings underscore the importance of evaluating MDC soon after injury and over time in all individuals with TBI.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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List of Abbreviations (in alphabetical order)

ANOVA	analysis of variance
CCTI	Capacity to Consent to Treatment Instrument
CT scan	computed tomography scan

cmTBI	complicated mild TBI
GCS	Glasgow Coma Scale
GOAT	Galveston Orientation and Amnesia Test
MDC	Medical Decision Making Capacity
MRI	Magnetic Resonance Imaging
msevTBI	moderate to severe TBI
mTBI	mild TBI
PTA	posttraumatic amnesia
S	standard
TBI	Traumatic Brain Injury
UAB	University of Alabama at Birmingham

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Highlights

- Many TBI patients have impaired medical decision making capacity (MDC) 1 month post-injury
- Partial or full recovery of MDC occurs in many patients over first 6 months
- MDC outcomes depend on injury severity
- 20% of mild and 35% of complicated mild cases have impaired MDC 6 months after TBI
- 50% of moderate to severe cases have impaired MDC 6 months after TBI

Table 1

Causes of traumatic brain injury in the patient sample (n = 91)

Cause	No. of Patients	Percentage
Motor vehicle crash	50	54.9
Motorcycle crash	8	8.8
ATV/Go-cart crash	3	3.3
Assault with blunt instrument	4	4.4
Sports	2	2.2
Falls	18	19.8
Hit by falling or flying object	1	1.1
Pedestrian	1	1.1
Other	2	2.2

Table 2

Demographic and Clinical Characteristics of Study Participants

Variables	Range	Controls n = 60	mTBI n = 27	cmTBI n = 20	msevTBI n = 44	p [*]
Age (y)	19-70	35.6 (12.4)	36.0 (12.3)	42.3 (15.3)	35.6 (14.5)	.252
Female, n (%)		23 (38.3)	13 (48.1)	8 (40.0)	8 (18.2)	.044 ^a
Race, n (%)						
African American		16 (26.7)	13 (48.1)	3 (15.0)	6 (13.6)	
Caucasian		44 (73.3)	14 (51.9)	16 (80.0)	37 (84.1)	.024 ^b
Hispanic		0	0	1 (5.0)	1 (2.3)	
Education (y)	8-20	12.9 (1.5)	13.2 (2.0)	13.8 (3.0)	12.5 (2.6)	.183
GOAT score [†]	0-100	N/A	95.9 (4.9)	94.3 (7.2)	71.8 (30.5)	<.001 ^c
Baseline		N/A	94.3 (5.8)	96.4 (6.1)	91.8 (12.7)	.213
6 Month						
GCS score	0-15	N/A	14.4 (1.9)	14.5 (0.7)	5.8 (3.0)	<.001 ^c

Except for gender and race, values are mean (SD).

^{*} p value for omnibus test of group differences. Gender and race were calculated by using a χ^2 tests. Age, education, GOAT scores, and GCS scores were calculated by using one-way ANOVA.

[†] GOAT score missing for 1 cmTBI and 1 msevTBI at baseline; GOAT score missing for 1 mTBI at 6 month follow-up.

^a Subsequent pairwise comparisons using 2x2 χ^2 tests revealed msevTBI was significantly different from controls and mTBI groups ($\alpha \leq .05$).

^b Comparison between Caucasian versus non-Caucasian (African American and Hispanic) groups. Subsequent pairwise comparisons using 2x2 χ^2 tests revealed a greater proportion of non-Caucasians in the mTBI group compared to controls, cmTBI, and msevTBI groups ($\alpha \leq .05$).

^c Subsequent Games-Howell post hoc tests revealed mTBI and cmTBI > msevTBI ($\alpha \leq .05$).

Table 3

Performance on the CCTI Standards Across Six Month Follow-up by Group

	Controls				mTBI				cmTBI				msevTBI				Group × Time Interaction [‡]	
	T1	T2	p ¹	n=60	T1	T2	p ²	n=27	T1	T2	p ³	n=20	T1	T2	p ⁴	Baseline [*]		6 Mo [†]
Range	n=60	n=60			n=27	n=27			n=20	n=20			n=44	n=44				
S1, expressing choice	3.98 (0.1)	4.0 (0.0)	.317		3.9 (0.3)	3.9 (0.5)	.480		3.9 (0.5)	3.9 (0.3)	.655		3.5 (1.3)	4.0 (0.0)	.02	.114	.010 ^g	.034
[S2], reasonable choice, n (%)																		
Yes (1 point)	58 (96.7)	57 (95.0)	.649		27 (100)	27 (100)	1.0		20 (100)	19 (95.0)	1.0		38 (86.4)	44 (100)	.031	.027 ^g	.302	.056
No (0 points)	2 (0.3)	3 (5.0)			0 (0)	0 (0)			0 (0)	1 (5.0)			6 (13.6)	0 (0)				
S3, appreciation	7.5 (0.9)	7.5 (0.8)	.742		6.8 (1.3)	7.2 (1.0)	.246		6.9 (1.5)	7.0 (1.2)	.793		5.1 (2.7)	6.5 (1.7)	.001	<.001 ^a	.002 ^d	.001 ^e
S4, reasoning	8.8 (2.5)	8.8 (2.5)	.900		8.1 (2.4)	8.8 (2.5)	.225		7.1 (3.8)	8.6 (3.3)	.122		4.5 (3.5)	7.0 (3.1)	<.001	<.001 ^b	.008 ^g	.005 ^e
S5, understanding	64.3 (9.0)	64.5 (9.1)	.859		56.4 (11.3)	60.9 (12.3)	.011		49.8 (18.7)	57.3 (14.4)	.025		31.7 (20.5)	48.7 (17.1)	<.001	<.001 ^c	<.001 ^b	<.001 ^f

Note: Except for S1 and [S2], values are mean (SD).

T1 = Time 1 (Baseline); T2 = Time 2 (6 month follow-up)

p¹ = Within control group difference from Time 1 to Time 2

p² = Within mTBI group difference from Time 1 to Time 2

p³ = Within cmTBI group difference from Time 1 to Time 2

p⁴ = Within msevTBI group difference from Time 1 to Time 2

Within group change was analyzed using Wilcoxon tests (S1), McNemar's test [S2], and paired *t* tests for S3-S5.

Baseline and 6 month group comparisons were analyzed with Kruskal-Wallis (S1), χ^2 tests [S2], and a one-way ANOVA (S3-S5). Subsequent post hoc tests were conducted using Mann-Whitney (S1), pairwise χ^2 tests [S2], and Games-Howell tests (S3-S5).

Change over time was analyzed using Friedman test with Wilcoxon post hoc tests (S1, [S2]). S3-S5 analyzed using repeated-measures ANOVA with Games-Howell post hoc tests.

Holm's adjustment was used for all post hoc tests (α .05).

* = *p* value for omnibus test of group differences at baseline

[†] = *p* value for omnibus test of group differences at 6 months

[‡] = group × time interaction over 6 months on CCTI variables between controls, mild TBI, complicated mild TBI, and moderate/severe TBI groups.

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d = controls, mTBI, cmTBI > msevTBI

b = controls, mTBI > msevTBI

c = controls > mTBI, cmTBI > msevTBI

d = controls > msevTBI

e = msevTBI showed greater amount of improvement compared to controls

f = msevTBI showed greater amount of improvement compared to controls and mTBI

g = none of the posthoc comparisons were significant after Holm adjustment

Table 4
Capacity Impairment Ratings on CCTI Consent Standards (S) Across Time for Traumatic Brain Injury Patient Groups

Standards	Baseline			6 Month Follow-Up		
	Intact	Mild/Moderate Impairment	Severe Impairment	Intact	Mild/Moderate Impairment	Severe Impairment
S1, expressing choice						
mTBI	25 (92.6)	2 (7.4)	0 (0)	24 (88.9)	2 (7.4)	1 (3.7)
cmTBI	18 (90.0)	1 (5.0)	1 (5.0)	18 (90.0)	2 (10.0)	0 (0)
msevTBI	38 (86.4)	1 (2.3)	5 (11.4)	44 (100.0)	0 (0)	0 (0)
[S2], reasonable choice						
mTBI	27 (100.0)	-	0 (0)	27 (100.0)	-	0 (0)
cmTBI	20 (100.0)	-	0 (0)	19 (95.0)	-	1 (5)
msevTBI	38 (86.4)	-	6 (13.6)	44 (100.0)	-	0 (0)
S3, appreciation						
mTBI	18 (66.7)	4 (14.8)	5 (18.5)	22 (81.5)	3 (11.1)	2 (7.4)
cmTBI	14 (70.0)	2 (10.0)	4 (20.0)	13 (65.0)	5 (25.0)	2 (10.0)
msevTBI	18 (40.9)	7 (15.9)	19 (43.2)	25 (56.8)	8 (18.2)	11 (25.0)
S4, reasoning						
mTBI	23 (85.2)	4 (14.8)	0 (0)	25 (92.6)	2 (7.4)	0 (0)
cmTBI	13 (65.0)	5 (25.0)	2 (10.0)	17 (85.0)	1 (5.0)	2 (10.0)
msevTBI	18 (40.9)	12 (27.3)	14 (31.8)	29 (65.9)	12 (27.3)	3 (6.8)
S5, understanding						
mTBI	19 (70.4)	4 (14.8)	4 (14.8)	22 (81.5)	2 (7.4)	3 (11.1)
cmTBI	11 (55.0)	2 (10.0)	7 (35.0)	15 (75.0)	4 (20.0)	1 (5.0)
msevTBI	7 (15.9)	7 (15.9)	30 (68.2)	21 (47.7)	11 (25.0)	12 (27.3)

Note. Values are n (%).

mTBI sample size = 27; cmTBI sample size = 20; msevTBI sample size = 44